

Constraints On Smallholder Dairying In Swaziland; Manzini Region & Surrounding Areas

by

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Thesis

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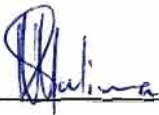
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Declaration

I Mr Boyce T. Malima hereby declare that the research reported in this thesis is the result of my own investigations, except where acknowledged, and has not, in its entirety or part been previously submitted to any University or Institution for degree purposes.

Signed  _____

I Prof. Nsahlai, I.V., Chairperson of the supervisory committee, approve release of this thesis for examination.

Signed  _____

Acronyms

| | |
|--------|---|
| AI | Artificial Insemination |
| CIDA | Canadian International Development Agency |
| GLM | Generalised Linear Modelling |
| LH | Luteinising Hormone |
| LSU | Livestock Unit (A 450kg animal) |
| MOAC | Ministry of Agriculture & Co-operatives |
| NEBAL | Negative Energy Balance |
| PCA | Principal Components Analysis |
| RDA's | Rural Development Areas |
| SDDDB | Swaziland Dairy Development Board |
| SNL | Swazi Nation Land |
| TDL | Title Deed Land |
| TDN | Total Digestible Nutrients |
| UNISWA | University of Swaziland |
| UHT | Ultra High Temperature Treatment of Milk |

Summary

Swaziland has long had a disparity between the supply and demand of milk. Even at present milk production continues to be less than the market demand. The quantitative contribution of smallholder dairy farmers to local milk production remains unknown because of poor record keeping. This study was aimed at attaining a clear understanding of the dynamics of smallholder dairying in Swaziland, including the identification and understanding of the constraints faced by farmers in dairying, with the hope of devising workable solutions to them.

A sample of 118 smallholder dairy farms were covered in this study, with a total herd of 306 lactating cows, comprising mainly of Jerseys and Holstein Friesians, with some cross breeds. There were no significant differences in mean milk yield/cow with respect to farmer gender ($P > 0.05$) and Agro-ecological zone location ($P > 0.05$) of the farms. Milking frequency had a significant effect on milk yield, since cattle milked once a day had lower ($P < 0.05$) milk yields than those milked twice a day. The cattle had extensively long calving intervals i.e. 448 ± 166 days, ranging from 292 to 1082 days. Low milk yield and poor reproductive performance of cattle were found to be mainly due to poor nutrition, breeding practices and stock quality. These are primarily a result of insufficient farmer training and inadequate technical assistance, scarce availability of quality stock, lack of investment resources and market support that includes favourable milk prices for farmers to make money.

This performance of the Swazi smallholder dairy herd was then evaluated by comparing it to the performance of a larger, well-managed herd of known pedigree. Lactation records from 252 Jersey cows and 108 Holstein Friesian cows were obtained from Cedara Agricultural Research Institute, covering the periods; July, 2002 to July, 2004 and November, 2002 to April, 2004, respectively. Cows were grouped by parity and calving season and the gamma

function proposed by Wood ($Y = An^be^{-cn}$) was used to fit standard lactation curves on group data. The curve parameters A and b increased with parity, while that of c and s (persistence of lactation at peak) decreased, producing standard lactation curves save for the Holstein Friesian summer calvers, which produced atypical curves. The R^2 values (goodness of fit) increased with parity. Animal parity and calving season were found to influence the peak and shape of the lactation curves and their parameter estimates. The performance of the Swazi smallholder herd showed a mean deviation of the observed daily milk yield of the Holstein Friesian breed from the expected yield to be -3.47 (SD 6.052) kg and that of the Jersey breed was -16.92 (SD 5.473) kg. The mean proportional deviation of observed milk yield from the expected yield for the Holstein Friesian breed was -0.3 (SD 0.37) and that of the Jersey breed to be -0.6 (SD 0.19). The proportional milk yield deviation of the Holstein Friesian breed can be explained using the equation $Y = 0.1322(\text{SE} = 0.1293) x - 2.3581$ (SE = 0.20639), where x = expected milk yield and Y is the proportional deviation of the observed milk yield deviation from the expected milk yield. With respect to the smallholder Jersey breed, no relationship was found that could explain the proportional milk yield deviation. The smallholder herd was shown to be underperforming, considering the potential for higher milk yields of the two breeds.

In the quest to gain a greater understanding of the dynamics of smallholder dairying, the sample of 118 farmers was further analysed using multivariate statistics to categorise them based on their herd sizes, herd structures, management and success perceptions in dairying. The analysis produced three clusters (categories): cluster 1 had the largest herd sizes and poor milk production efficiency; cluster 2 had intermediate herd sizes, the highest number of farmers and more efficient milk production per cow. This cluster, however, had the highest proportion of calf mortalities. Cluster 3 had the smallest herd size, the lowest calf to cow ratio and the second highest calf mortality. Record keeping across all clusters was very poor and the average milk yield per cow was generally low. Most of the farmers do not appreciate the importance of annual calving of their cows as an integral part of the success of their dairy

projects and winter feed supplementation is very poor across all the clusters. There remains a great need for the enlightenment of the farmers on the importance of good nutrition, breeding, calf rearing and record keeping in successful dairying.

Dedication

This thesis is dedicated to my entire family and all my friends in appreciation of their support, encouragement and prayers throughout the duration of my studies for this master's programme.

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Table of Contents

| | |
|--|------|
| Declaration..... | ii |
| Acronyms..... | iii |
| Summary..... | iv |
| Dedication..... | vii |
| Acknowledgements..... | viii |
| 1.0 A General Introduction To Smallholder Dairying In Swaziland..... | 1 |
| 1.1 Country Background..... | 1 |
| 1.2 History of Dairying In Swaziland..... | 3 |
| 1.3 Dairy Herd & Stock Acquisition..... | 6 |
| 1.4 Breeding..... | 11 |
| 1.5 Calf Rearing..... | 14 |
| 1.6 General Animal Health..... | 15 |
| 1.7 Grazing & Feeding..... | 17 |
| 1.8 Milk Collection & Marketing..... | 22 |
| 1.9 Objectives of The Study..... | 25 |
| 2.0 Smallholder Dairy Production In Swaziland (Manzini & Surrounding Areas)..... | 27 |
| 2.1 Introduction..... | 27 |
| 2.2 Materials & Methods..... | 30 |
| 2.3 Results & Discussion..... | 31 |
| 2.3.1 Herd Structure & Composition..... | 32 |
| 2.3.2 Breeding..... | 36 |
| 2.3.3 Milking Management..... | 38 |
| 2.3.4 Pasture & Fodder..... | 42 |
| 2.3.5 Milk Yield..... | 45 |

| | |
|---|----|
| 2.3.6 Milk Marketing & Economics..... | 46 |
| 2.4 Conclusion..... | 49 |
| 3.0 Performance Deviation From Standard Lactation Curves..... | 51 |
| 3.1 Introduction..... | 52 |
| 3.2 Materials & Methods..... | 53 |
| 3.2.1 Source of Data..... | 53 |
| 3.2.2 Fitting of The Model..... | 54 |
| 3.2.3 The Swazi Smallholder Herd..... | 55 |
| 3.3 Results & Discussion..... | 56 |
| 3.3.1 The Cedara Herds..... | 56 |
| 3.3.2 Comparative Analysis of Smallholder Herd..... | 60 |
| 3.4 Conclusion..... | 65 |
| 4.0 Typology & Constraint Identification of Smallholder Producers..... | 68 |
| 4.1 Introduction..... | 68 |
| 4.2 Materials & Methods..... | 69 |
| 4.3 Results & Discussion..... | 71 |
| 4.3.1 Principal Components Analysis..... | 75 |
| 4.4 Conclusion..... | 80 |
| 5.0 General Discussion, Conclusion & Recommendations..... | 82 |
| 5.1 Conclusion & Recommendations..... | 84 |
| References..... | 86 |
| Annexure..... | 93 |
| Annex 1 Pictures showing the Feeding, Milking, Fodder Production & Conservation..... | 93 |

List of Tables

| | | |
|------------------|---|----|
| Table 1.1 | Physiographic Zones of Swaziland..... | 2 |
| Table 1.2 | Profiles of Dairy Farms In Swaziland..... | 8 |
| Table 1.3 | Milk Demand & Supply In Swaziland..... | 8 |
| Table 2.1 | Breakdown of The Total Herd Used In The Study..... | 33 |
| Table 2.2 | Breed Distribution In Smallholder Farms..... | 33 |
| Table 2.3 | Reproductive Performance..... | 36 |
| Table 2.4 | Daily Milk Yield of Different Breed Combinations..... | 39 |
| Table 2.5 | Proportions of Lactating Cows According To Herd Breed Composition And Farms..... | 40 |
| Table 3.1 | Lactation Curve Parameters For The Jersey Herd..... | 58 |
| Table 3.2 | Lactation Curve Parameters For The Holstein Friesian Herd..... | 58 |
| Table 4.1 | Cluster Means of Classification Variables & Group Means For The First Two Discriminant Functions For A 3-Cluster Solution..... | 72 |
| Table 4.2 | Total Sample Standardised Canonical Coefficients of Discriminant Variables..... | 73 |
| Table 4.3 | GLM Procedure Means & Standard Deviations of Each Discriminant Variable In All Three Clusters..... | 74 |

List of Figures

| | | |
|--------------------|---|----|
| Figure 2.1 | Milk Yield Comparison Between Breeds..... | 40 |
| Figure 3.1 | Lactation Curves of The Cedara Jersey Herd..... | 60 |
| Figure 3.2a | Lactation Curves of Holstein Friesian Herd (Winter Calvers)..... | 62 |
| Figure 3.2b | Lactation Curves of Holstein Friesian Herd (Summer Calvers)..... | 62 |
| Figure 3.3a | Comparison of Observed & Expected Milk Yield of Holstein Friesian Cows..... | 63 |
| Figure 3.3b | Comparison of Observed & Expected Milk Yield of Jersey Cows..... | 63 |
| Figure 3.4a | Proportional Milk Yield Deviation of The Observed Yield From The Expected (Holstein Friesian)..... | 64 |
| Figure 3.4b | Proportional Milk Yield Deviation of The Observed Yield From The Expected (Jersey)..... | 64 |
| Figure 3.5 | PCA Scatter plot of Performance & Management Variables For The 118 Smallholder Farmers..... | 76 |
| Figure 3.6 | PCA Triplot of Farmers (Samples), Herd Structure, management, Performance (Species) & Farmers' Success Perceptions..... | 79 |

Chapter I

A General Introduction To Smallholder Dairying And The Dairy Industry In Swaziland

1.0 Introduction

1.1 Country Background

The Kingdom of Swaziland is a sub-tropical country, located on the southeastern portion of southern Africa between latitudes 25°30' and 27°30'S and longitude 30°45' and 32°07'E. It is a land locked country, almost entirely surrounded by South Africa save for the eastern portion bordering Mozambique. The country experiences distinct wet (September – March) and dry seasons (April – August) each year, with their respective periods varying of late perhaps due to the El Niño and La Niña phenomena. Swaziland has fairly good soils and a variety of agro-ecological zones and therefore has a great potential for agriculture. There are six agro-ecological zones when considering the country's physiography; namely the Highveld, Upper Middleveld, Lower Middleveld, Eastern Lowveld, Western Lowveld and the Lubombo plateau (Sweet and Khumalo, 1994). The characteristics of the agro-ecological zones are shown in Table 1.1.

Administratively, Swaziland is divided into four regions (Hhohho, Manzini, Shiselweni & Lubombo), which span across the agro-ecological zones. The land tenure system of the country has two main categories, namely Title Deed Land (TDL) and Swazi Nation Land (SNL). Swazi Nation Land accounts for a majority of the land and is held by His Majesty The King in trust of the nation, and administered through chiefs who each have an area of responsibility, known as a chiefdom. As a result, the individuals or families using the land do not actually own it (legally) and hence cannot use the land as surety for loan acquisition. In each chiefdom, a family is allocated enough land to build a homestead and grow crops by the traditional authorities, the size of which depends on the amount of available land and the demand for human settlement and crop production. Title deed land on the other hand is

owned by individuals and is made up of farms (commercial), urban, suburban and industrial areas.

Table 1.1: Physiographic zones of Swaziland (FAO, 1994; Sweet and Khumalo, 1994).

| Physiographic zones | Area (km ²) | Altitude (m) | Rainfall (mm) | Geology | Vegetation Type |
|-----------------------|-------------------------|--------------|---------------|-----------------------|--|
| Highveld (HV) | 5 680 | 900-1400 | 700-1200 | Granite | Short grassland with forest patches |
| Upper Middleveld (UM) | 2 420 | 600-800 | 700-850 | Granodirite Granite | Tall grassland with scattered trees and shrubs |
| Lower Middleveld (LM) | 2 420 | 400-600 | 550-700 | Gneiss | Broad leaved savannah |
| Western Lowveld (WL) | 3 410 | 250-400 | 450-550 | Sandstone/ Clay stone | Mixed savannah |
| Eastern Lowveld | 1 960 | 200-300 | 400-550 | Basalt | Acacia savannah |
| Lubombo Ridge | 1 480 | 250-600 | 550-850 | Ignimbrite | Hillside bush and plateau savannah |

In Swaziland there is a positive correlation between altitude and rainfall, hence there is a gradation from sweet grasses in the Lowveld through moderately sour, or mixed grasses in the Middleveld, to predominantly sour grasses in the Highveld, with the recommended stocking rates decreasing from 2.0 – 2.3 Ha/LSU to 2.8-3.4 Ha/LSU from the highveld to the Lowveld (Sweet and Khumalo, 1994).

The Swazi nation is traditionally an agricultural nation, with almost every homestead (on SNL) keeping a variety of livestock (indigenous and exotic cattle breeds, goats, free range chickens, sheep and indigenous pigs) and growing crops, mainly maize. Keeping cattle is the most dominant type of livestock enterprise in the nation's agriculture sector (traditionally beef cattle only on SNL and very few exotic dairy breeds), although the trend is now changing to small stock and an increasing number of farmers venturing into smallholder dairy projects.

Some factors that have contributed to the change to small stock are (Personal observation):

- Reduced communal grazing land availability in response to the growing human population and settlement;
- Increasing health consciousness of the public concerning excessive red meat consumption;
- The growing popularity of poultry and pigs coupled with market availability for their products which is driven by government and industry, backed by capital availability primarily from government's enterprise fund and the regional development fund;
- The lucrative sugar cane production, which has of late led to the conversion of some communal grazing lands into cane fields by community based farmer groups; and
- Increasing incidence of drought spells in the wet seasons, leading to forage shortage and loss of productivity in the cattle and stock losses.

The Economic Planning Office (1995) reported that the distribution of cattle between farmers on SNL and TDL had remained unchanged over the years, with 83% of the total population of cattle owned by farmers on SNL. In the year 2000, a livestock census draft report by the Ministry of Agriculture & Co operatives (MOAC) stated that 84.3% of the total cattle population was still owned by farmers on SNL. This may not be the case in the distant future given that the human population is still increasing and so is the demand for land, with crop production and human settlements taking precedence over livestock production (mainly cattle) as a form of land use on SNL.

1.2 History of dairying in Swaziland

Organised dairying in Swaziland started in the late 1930's although the marketing of locally produced pasteurised milk only started in the late 1960's (FAO, 1998). Swaziland received her independence in the year 1968 and a dairy act was enacted (SDDDB, 2002b). The act enabled government to establish the Swaziland Dairy Board (SDB) in 1971, a parastatal organisation tasked with the development and regulation of the dairy industry in the country.

The SDB was set to work in collaboration with the MOAC and; as such, augments government's efforts to promote and sustain the dairy industry in the country (SDDB, 2002b). In 1979, the SDB, using technical advice and support from the Canadian International Development Agency (CIDA), established a government owned milk processing and distribution company (FAO, 1994) also known as the Swaziland Dairy Board – Dairy plant, located in the Manzini region (Matsapha Industrial site). The SDB was for a long time the only formal market to which dairy farmers could sell their milk. At this stage the SDB played many roles i.e. as a milk producer, raw milk buyer & processor, quality controller and industry regulator.

In the 1970's, MOAC embarked on a drive to improve agricultural production on SNL in both crop production and livestock farming. This was a donor-funded programme in which the country was divided into service delivery areas that were termed, rural development areas (RDA's). The programme consisted of many agricultural projects, which were well funded, had the needed equipment and staff. One of these projects was the establishment of organised dairying in the rural areas (FAO, 1996). The original plan was to establish five milk collection schemes. The smallholder farmers would pool their daily milk yields into the bulk cooling tankers at the milk collection centres located in the strategic RDA's and from there the milk would be collected by SDB for processing. The farmers would then be paid according to the quality and quantity of milk produced. There is, however, only one of these milk collection schemes and centres that has remained functional to date, the Luyengo settlement scheme in the Manzini region.

Over time the SDB was able to set up an efficient network of raw milk collection primarily from large scale commercial and some smallholder farmers, using milk tankers. It established a high standard of milk processing into high quality products such as pasteurised milk, culture fermented milk (emasi), yoghurt and dairy juices. The distribution of the finished products also improved with time, as a good distribution network was established in both the

urban and rural areas. The monopoly enjoyed by the dairy board and its aggressive marketing strategies facilitated its growth and dominance in the Swazi dairy industry. FAO (1996) identified low milk prices as the main cause for poor development of the smallholder dairying in the country as well as the failure of smallholder milk collection schemes that had been set up. In accordance with the dairy act, milk prices were set by MOAC in consultation with the SDB. The minimum producer price of fresh milk and the maximum wholesale and retail prices for milk and sour milk (emasi) were those specifically set (FAO, 1996).

The price setting system was not very efficient since there were often delays in the adjustments of milk prices in response to escalating production costs. This impacted negatively on local milk production, thereby compelling SDB to rely heavily on imported milk to meet the market demand. Gazetted milk prices were eventually adjusted in 1990 and from then were adjusted on an annual basis. In the 1990s, all stakeholders in the dairy industry agreed that the deregulation of dairy prices would stimulate production and promote investment in the industry. This would encourage market competition; improve production and marketing efficiency to the benefit of the consumer. In October 1999, the government removed the price control of milk and other dairy products but maintains control on import prices (by imposing levies) to avoid dumping of cheaper foreign dairy products in the country (SDDDB, 2002b). Until February 1997, the SDB refused to allow imports of UHT (sterilised milk) and fresh milk to competitors in the country. Levies are charged on milk and dairy product importers into the country to avoid unfair market competition.

To date, Swaziland imports a lot of milk, mostly in the form of milk powder. The main importers are Cadbury and Family Fun but there are many other smaller companies that import and distribute milk and dairy products in the country. The imported milk powder is normally used in the manufacturing of milk-based products like chocolates, sweets, confectionaries and juices for both the local and export market. The high import levels present a compelling case for the improvement of milk production in the country since the

market demand exists and is evidently beyond local production levels. In 1998 a restructuring process of the SDB began in preparation for the separation of the regulatory and commercial functions leading to the privatisation of the Matsapha dairy plant into a joint venture company (Parmalat, Swaziland). This process of restructuring and separation was completed at the end of October 1999. The SDB was renamed to become the Swaziland Dairy Development Board (SDDB), now with a core function to provide developmental and regulatory services to the dairy industry from a neutral position. The SDDB is furthermore expected to co-ordinate, harmonise the production and consumption of quality dairy products, and, where necessary, to regulate the activities of all role-players in the interest of the industry (SDDB, 2000b).

The SDDB has about four extension officers that work in collaboration with four dairy extension officers from the MOAC (one in each administrative region). The whole country therefore has only eight officers designated to educating and advising smallholder dairy farmers on suitable dairy husbandry practices. The number is insufficient since the MOAC staff has the added problem of not having enough transport facilities to get to the farmers and has an increasingly diminishing budget from which to operate.

1.3 Dairy Herd and Stock Acquisition

In the late 1930's, when organised dairying started in Swaziland, it was originally centred on a private dairy in Manzini. Its main activities were buying cream from a network of depots and collecting milk from smallholder beef herds along the Manzini-Siteki road (FAO, 1994). The indigenous Nguni cattle have, for generations, been used as a multipurpose breed by the Swazi nation i.e. for meat, milk and draught purposes. The Nguni cows produced enough milk for both calf rearing and feeding the farming families, especially since milk was abundant during the wet season. Historically the seasonality of milk abundance was not a problem since the country has always experienced distinct wet and dry seasons. In the wet season there has always been an abundance of food from the variety of planted field crops

(especially maize), vegetables, wild growing fruits and wild vegetables. The harvested grain and other vegetable crops such as pumpkins etc would either be stored in pit silos (tingungu) or in cribs and consumed in the winter by the families.

As time went by, exotic breeds of cattle were introduced in the country, both *Bos indicus* (e.g. Brahman) and *Bos taurus* (e.g. Simmental, Jersey, Holstein Friesian). Most of the Nguni cattle on SNL were crossbred indiscriminately with these breeds, owing to the communal grazing system practised, hence a non descript breed of cattle emerged from the unplanned cross breeding. Inbreeding amongst the Nguni breed alone could also not be prevented under this grazing system, resulting in an increasingly homogenous population of Nguni cattle. The homogeneity is undoubtedly expected to have had adverse effects on the milk yielding capacity of the Nguni cattle. On the other hand, the cross breeding would have been expected to improve milk yield, perhaps if it were in an organised fashion. Vilakati (1994) reported that Nguni cattle crossbreeds had improved reproductive and maternal performance, indicating perhaps an improvement in milk yield as well.

The increase in the country's population especially in the urban areas resulted in an increasing number of milk consumers who did not have their own animals to milk. This in turn meant that the demand for milk in the formal market increased. The contributors to the formal milk market have always been a few large-scale commercial farmers on TDL and a number of smallholder dairy farmers on SNL (Table 1.2). The commercial farms supply the bulk of the milk collected from Swazi farmers and they either keep Holstein Friesian, Jersey or a mixture of both breeds. The smallholder farmers on the other hand initially kept the Nguni breed only, but with time have changed to predominantly the Jersey, some Holstein Friesian, Ayrshire, Guernsey and their cross breeds. The two most popular breeds, however, are the Jersey and Holstein Friesian, perhaps as a result of their abundance, established history with farmers and especially the adaptability of the Jersey.

Table 1.2: Profile of dairy farms in Swaziland (SDDB Annual Reports 1998-2002a).

| Year | Number of Farmers | | | Number of Dairy Cattle | | |
|------|-------------------|-----|-------|------------------------|------|-------|
| | SNL | TDL | Total | SNL | TDL | Total |
| 1998 | 486 | 113 | 599 | 2393 | 3293 | 5623 |
| 1999 | 628 | 127 | 755 | 3106 | 3867 | 6973 |
| 2000 | 657 | 140 | 797 | 3502 | 3935 | 7437 |
| 2001 | 679 | 139 | 818 | 3477 | 3789 | 7266 |
| 2002 | 673 | 129 | 802 | 3445 | 3710 | 7155 |

Table 1.2 illustrates an increasing trend in the population of smallholder dairy farmers on SNL and commercial farmers on TDL in the past years. There has been of late a decline in the numbers of both commercial and smallholder dairy farms as a consequence of a myriad of reasons, the most common of which are the death of the project owners, old age, decline in stock productivity with age coupled with inability to acquire new stock, scarcity of replacement stock, low income from raw milk sales to processors in the face of escalating production costs; lack of innovative and efficient management strategies.

Table 1.3: Milk demand & supply in Swaziland (SDDB Annual Reports 1998-2001).

| Year | Demand (LME's) (l) | Supply (LME's) (l) | Deficit (LME's) (l) |
|-----------|--------------------|---------------------|---------------------|
| 2000-2001 | 61.5×10^6 | 11.60×10^6 | 49.90×10^6 |
| 1999-2000 | 63.9×10^6 | 11.54×10^6 | 52.36×10^6 |
| 1998-1999 | 60.7×10^6 | 11.10×10^6 | 49.60×10^6 |
| 1997-1998 | 57.6×10^6 | 10.30×10^6 | 47.30×10^6 |

LME: Liquid Milk Equivalents

The apparent increase in cattle and farmer population has however not been able to meet the demand for milk in the country. FAO (1996) reported that 60% of the milk consumed in the country was being imported from neighbouring countries. The situation has not changed much even today, as shown in Table 1.3. It should, however, be noted that the indicated demand for milk includes milk powder imported by companies solely for manufacturing dairy based products for both domestic and mostly export markets. Kenya is broadly self-sufficient in milk and dairy products, with over 400 000 smallholder dairy farmers producing more than 70% of the marketed milk in the country (Reynolds *et al.*, 1996). Weldeselasia (2003)

reported that in Ethiopia, small-scale producers supply almost 88% of all urban milk as raw milk through the informal market and that a few large farms or collective marketing organizations exist.

1.3.1 Stock Acquisition

Swaziland does not have a functioning dairy breeding facility. The government established Gege dairy farm for the purpose of training farmers, staff and breeding good quality stock for the dairy industry. This farm is at present being under-utilised and has not lived up to the ideal of providing affordable replacement stock of high genetic merit to Swazi farmers. The reasons for the current situation are the lack of clear-cut government policies that could be the instrument for the implementation, funding and personnel availability for such a highly technical and costly project. At present both Jersey and Holstein Friesian cattle are imported from South Africa and used as replacement stock. These importations are facilitated by the SDDB and MOAC, mostly for smallholder farmers. The farms from which the cattle are imported are those with pedigree records and registered animals. Most commercial and some smallholder farmers however privately import their animals from wherever they please, as long as they meet the import requirements.

There are numerous farmers who want dairy cows to either increase their herd sizes or replace culled or lost stock. The cost of a pedigree cow is often very high and most farmers cannot afford to buy more than one cow at a time. When imported, there are extra costs related to the quarantining of the animals in both countries before and after their importation, including the feeding and transportation during this period. The transportation costs are either borne by MOAC or SDDB, however, the quarantine costs are either directly borne by the individual farmers or at times by SDDB. Ideally for the farmers to receive the animals they need to have already established a pasture, crush pen, milking parlour and received some education on dairy husbandry. Both the MOAC and SDDB dairy extension staff jointly

provide this training and advice. Upon meeting these requirements the farmers are then registered on the SDDB acquisition list and cattle are then sought from willing sellers in neighbouring South Africa.

The potential problem with this system, however, is that the farmers from which these cattle are bought are normally still fully engaged in dairy farming and hence would not be expected to sell their good animals unless the population is beyond what they could cater for. It follows therefore that some of the animals that are bought through this system are likely to be culls from these farms, unless that particular farm is selling all its stock and closing down. Some Swazi farmers who have the resources (financial and transport) bypass both MOAC and SDDB and directly purchase stock from South Africa. These farmers often approach MOAC and SDDB dairy staff looking for hay, feed and advice when the animals have already arrived and are either starving or ill, having not made the necessary arrangements for their accommodation. As of December 2002, MOAC has been able to provide a small number of smallholder farmers with dairy stock from the Gege dairy farm at subsidised prices (below market cost). These cattle are sold exclusively to smallholder dairy farmers who have met the same preparation prerequisites imposed on farmers who receive imported stock. The number of animals sold annually is, however, far below the demand for dairy stock by smallholder farmers. Hence a sound breeding programme has to be put into place to meet the demand and to ensure proper implementation, should be well funded and supplied with the needed technical staff and labour.

According to Alejandrino *et al.* (1999), in the Philippines, crossbred Holstein Friesian X Sahiwal dairy cattle have been imported from New Zealand since 1986 and dispersed to farmers to meet the urgent need for breeding stock. Milk production is mainly carried out by smallholder farmers and barely meets 5% of the country's milk demand, a factor attributed to poor dairy breed availability, management of animal nutrition, and breeding as the main constraints on dairy cattle productivity (Alejandrino *et al.*, 1999).

1.4 Breeding

The large and medium scale commercial farmers on TDL primarily rely on artificial insemination (AI) for their breeding. Bulls, if any, are kept only to service those cows that have difficulty conceiving by means of AI. The semen used is normally imported from South African companies that have catalogues of registered, performance-tested bulls from around the world. These companies have agents that order and distribute the catalogues and semen to farmers. This set up is favourable to the commercial farmers since they have the necessary equipment, capital, skills and (or) have access to personnel with AI skills.

The smallholder farmers on the other hand have fewer animals, less capital, and often poor or no knowledge of AI. The SDDB provides AI services primarily to smallholder farmers. The problem, however, is that most farmers do not keep breeding records and hence do not even know when their animals are expected to be on heat and subsequently require servicing. The terms of the service provision by SDDB are that the farmer calls their office once the cow is detected to be in heat so that they can inseminate her about 8 -12 hours later. The farmer is also charged according to the class of the bull whose semen is utilised, after having been given advice on the use of the best bulls that are affordable. The lack of record keeping, heat detection knowledge, capital and communication difficulties often stifle the AI service provision programme by SDDB. Synchronised oestrus and subsequent AI is an alternative way to circumvent the poor record keeping and communication but it implies additional costs of the drugs used, and as a result only a few farmers utilise this service.

Most smallholder farmers prefer the use of bulls for breeding, even though most of them hardly have enough pasture for their cows to graze on (presumably because the presence of a bull alleviates the obligation of the farmers to keep track of the oestrous cycle of the cows for breeding purposes). This is compounded by the fact that there is no breeding centre for dairy bulls in the country, hence, farmers primarily resort to the use of any dairy male for breeding.

The common practice is that those that can afford to, buy male cull calves from the commercial farms, rear them and then use them as breeding bulls. Those that can not afford to buy cull calves resort to borrowing of dairy bulls from neighbours and if unsuccessful they crossbreed the cow with any available breed to safeguard continued production. The cattle are at times left open for extended periods of time while the farmers persist to milk them, even with the dwindling yields.

These poor breeding practices have the effect of regressing the milk production potential of the resulting generations since the animals are either inbred, reducing their genetic variation or crossbred with non-dairy breeds. The influential veteran farmers sometimes sell the resulting crossbreed offspring to the novice aspiring smallholder farmers as purebred dairy animals since their phenotype to some extent resembles that of the pure breed. Given this situation, there is a possibility that the numbers of both smallholder dairy farmers and animals have been seen to be on the increase whilst the total milk production has not increased proportionally. This could be due in part to the fact that the potential and actual milk production per animal has declined as a result of a reduction in the genetic potential for high milk yield. The exotic dairy breeds have been observed to have superior performance as dairy animals in terms of their milk yields, lactation length and calving intervals when compared to the indigenous breeds and their crosses (Tambi, 1991; Mutukumira *et al.*, 1996; Masiteng and van der Westhuizen, 2001; and Weldeselasia, 2003).

In Cameroon, Tambi (1991) reported that milk production was not only limited by the poor performance of the local breeds (Gudalis, White and Red Fulani) but also by the shortage of high quality exotic and/or crossbred animals. In a case study conducted in the North-eastern Free State in South Africa, Masiteng and van der Westhuizen (2001) noted that the farmers keep a variety of breeds, ranging from the indigenous, beef breeds, cross breeds to the exotic dairy breeds. Under the communal grazing system breeding is mainly by the use of bulls, of which 68.5% are non-registered, 28.8% are registered and 2.7% of farmers use AI.

In Zimbabwe, Mutukumira *et al.* (1996) reported that the smallholder dairy farmers kept both the exotic (Red Dane, Jersey and Friesian) and indigenous (Mashona) breeds and their crosses. Furthermore the Dairy Development project in Zimbabwe provides registered bulls to the farmers for breeding purposes and occasionally provides AI services. According to Weldeselasia (2003), in Eritrea most farmers (86.7%) used natural mating, 3.3% used AI and 10% used a combination of the two breeding systems. Of those that used natural mating, only 57% owned bulls while the rest (43%) hired the bulls.

In an attempt to curb the poor breeding situation, in the year 2001, SDDDB identified, and started training key farmers from different communities on the oestrous cycle of cattle, heat detection and AI. These smallholder farmers were upon training, provided with all the AI equipment (liquid Nitrogen flasks, semen straws, insemination guns and gloves) with which to return to their respective communities with the prospect of facilitating easy access to AI service for farmers within those communities. The fundamental flaws of this programme have, however, been the extensive distances between the local AI skilled farmers and those that require AI services, scarcity of transport and telecommunication between the farmers and their AI skilled colleagues, lack of funds to pay for the semen used for AI and, more importantly, most farmers have no clue about when their cows are expected to come into heat and can only recognise the overt signs of heat. Furthermore most of these resource people are self-employed and therefore involved in a lot of activities, either at a personal or community level, hence they are often not available when needed. An unknown factor, however, is that of sustaining their motivation to do the work over time since it appears to merely be a voluntary community service at present.

Bergevoet *et al.* (2004) reported that there is a significant relationship between behaviour and the goals and intentions of farmers. Bebe *et al.*, (2003) stated that the breeding decisions of smallholder dairy producers in the Kenyan highlands conform to producers' objectives, which include; the need for increased milk production, adaptability to local feed

conditions and diseases and the provision of non-market production, ergo manure, insurance, financing and the social roles of cattle. Most smallholder farmers in developing countries favour the cross breeding of the indigenous and exotic dairy cattle breeds in an attempt to harness the positive traits of the different breeds (Pedersen and Madsen, 1998; Masiteng and van der Westhuizen, 2001; Bebe *et al.*, 2003; Weldeselasia, 2003; Kahi *et al.*, 2004). The reasoning being that the indigenous breeds are known to be well adjusted to their environmental conditions. They are either tolerant or resistant to most of the prevalent livestock diseases and pests and are generally hardy breeds. The exotic breeds on the other hand are less adapted to tropical conditions, parasites and diseases, however, they are known to produce high milk yields.

1.5 Calf Rearing

In the smallholder dairy production system, newborn calves are normally left to nurse on the dam around the clock for a period ranging from 3 days to a week. The calves are then bottle-fed on either cow milk after milking or on milk replacers and calf starter rations until they are at least 8 weeks old. Some farmers practise a controlled suckling strategy in which the calves are allowed to suckle on the dam either twice or three times a day for a limited period of time after milking. In this system, when milking, the farmer leaves behind a certain volume of milk in the udder estimated to be enough to feed the calf. Under controlled suckling, natural weaning (at about 6–10 months of age) is invariably practised by farmers. This however fosters a strong maternal bond between the dam and the calf, which has been shown to result in a prolonged postpartum anoestrus period (Bearden and Fuquay, 2000) and hence longer calving intervals result. The newborn calf is kept within the homestead while the dam is allowed to go and graze during the day until it is about two to three months of age and can graze independently.

According to Reynolds *et al.* (1996) in Kenya the survival rate of calves is affected by the value placed on them by farmers in that female calves are given more feed than males since the females are valuable for herd replacements and for sale to other farms. In a Tanzanian case study, Lyimo *et al.* (2004) reported that newborn calves were allowed to stay with the dam and suckle freely for more than four days, after which, they were placed on a restricted suckling system in which they would be used to stimulate milk let down in the dam and then allowed to suckle after milking. The calves were gradually weaned at an age of 4-6 months, as the farmers considered late weaning as a way to reduce nutritional stress and a necessity for stimulating milk let down before hand milking (Lyimo *et al.*, 2004).

Lyimo *et al.* (2004) further observed that while farmers appeared to be aware of the importance of feeding a balanced ration to growing animals, the quality and quantities of the provided feed seemed to be influenced by availability (of the feed ingredients) and resource allocation rather than the need to supply quality feed to the animals, contributing to the low calf survival and growth rates reported by farmers and key people interviewed.

1.6 General Animal Health

In a serological survey of bovine tick-borne diseases in Swaziland, Jagger *et al.* (1985) found African redwater, caused by *Babesia bigemina*, to be endemic to Swaziland. The tick-borne diseases, redwater (Bovine babesiosis) and gall sickness (Anaplasmosis) are big challenges to dairying in Swaziland. The Holstein Friesian breed of cattle appears to be less resistant to babesiosis than the Jersey breed and the indigenous Nguni breed. The strict weekly dipping and/or spraying of cattle with acaricides, practised in the country contributes to the susceptibility of the animals to the diseases since they are hardly exposed to the pathogens (protozoan parasites) and hence cannot develop and maintain the antibodies at titre levels required for the animals to gain tolerance to infections (Coetzer *et al.*, 1994; Mkhonta, 1994; Botha *et al.*, 1996; Malima, 1999). Heartwater (Cowdriosis), a tick borne disease caused by

the rickettsia, *Cowdria ruminantium* (Coetzer *et al.*, 1994) is also a problem to livestock owners in Swaziland, especially in the highveld areas.

There was a foot and mouth disease outbreak in late 2001 and early 2002 in the Lubombo and northern Hhohho regions in Swaziland. A lot of farmers lost their stock during this outbreak and hence some went out of business, especially beef farmers. Legislation states that state veterinarians should routinely test all dairy animals for bovine tuberculosis and bovine brucellosis (*Brucella abortus*) as a prerequisite for the producers to sell their milk for public consumption. This testing is, however, conducted only on the large-scale commercial farms that either sell milk to Parmalat or privately package and distribute milk to supermarkets. Since smallholder farmers do not need licences to sell milk in the informal market, their animals are seldom tested for these diseases. This is dangerous because both bovine tuberculosis and brucellosis are zoonotic and can be lethal. Mastitis is a common problem in most farms but most smallholder farmers know that practising good hygiene and milking practices go a long way in keeping the disease at bay.

The number of state veterinarians has increased with time in the country, with there being at least two veterinarians in each of the four administrative regions. These officers are invariably provided with the necessary transport in the form of government vehicles in order to facilitate improved service provision to farmers. In addition to veterinarians, there are veterinary assistants stationed within the communities, who advise farmers on animal health issues. Some situations, however, do inevitably require the direct attention of a veterinarian and in these situations; the question becomes whether or not they actually get that service and how long it takes to receive it. In spite of the present human resource, many smallholder farmers still express dissatisfaction with the state, animal health service provision. One of the contributing factors to this state of affairs could be the fact that the veterinary offices are stationed in the cities and towns, yet most livestock owners live out of town, in the rural areas. Another factor could be centred on communication, since most smallholder farmers

have no telephones through which to contact the veterinary office. Most rely on public transport to travel extensive distances and by the time they are able to get to the veterinary office, it is often too late. This communication problem invariably results in delayed or no treatment of sick animals. Consequently, more virulent diseases like redwater result in mortalities and where the animals recover, the farmers incur severe production losses.

According to Weldeselasia (2003), in Eritrea, available animal health (veterinary) services are thinly spread and ineffective, as are drug availability and distribution, furthermore, constraints to the successful control of diseases are not technological but related to the availability and cost of treatment. Comparatively the situation is slightly different in Swaziland in that veterinary drugs are widely distributed throughout the country through farm input retailers and farmer co-operative depots. The cost of the drugs is, to some extent, however, a limiting factor to their accessibility but the fact that state veterinarians are able to dispense small quantities of medication at cost to farmers offsets the high costs.

1.7 Grazing and Feeding

Swaziland has a number of agro-ecological zones and hence a variation in the agricultural potential in the different zones. The naturally growing tropical grass species range from the sweet veld in the Lowveld to the sour veld in the Highveld, resulting from the differences in rainfall, climate, soil types and pH (Sweet and Khumalo, 1994). Traditionally livestock kept on SNL would be allowed to graze on the open plains on communal pastures. Herds from different homesteads would share the vast resource during the day and in the evening the animals would be kraaled in the homesteads. In the dry season (winter), after grain harvesting, the animals would be allowed to graze on maize stalks left over in the cropping fields.

Over time, the population of livestock has increased and the pasture resource has increasingly declined in size as the land is continually being reallocated, primarily for human settlement and crop production. There has been for some time now a major concern about overstocking on the communal pastures since there is no existing system of control, imposing a limit on the number of animals that can be grazed by each homestead in each chiefdom. The overgrazing has resulted in extensive soil erosion in some areas and generally a change in the rangeland grass species composition to less palatable increaser species such as *Hyparrhenia hirta* and *Sporobolus* species (Sweet and Khumalo, 1994). Bushes have encroached into the rangelands with an increase in invader alien plant species such as *Lantana camara*, *Senna didymobotrya* and most recently *Chromolaena odorata* (Personal observation). The latter spreads rapidly, is extremely versatile and has allelopathic effects (toxicity) on other vegetation, which result in the inhibition of the growth of grasses and other plants in their vicinity. *Chromolaena* is present in South Africa, Swaziland, Mozambique and possibly Zimbabwe (Zachariades and Goodall, 2002) and impacts negatively on forestry, pastoral agriculture and natural vegetation (plant) biodiversity (von Senger *et al.*, 2002; Zachariades and Goodall, 2002). These factors compound the problem of a diminished grazing resource, as the livestock population (grazers and browsers) in the country remains high, the majority of which is on SNL.

Smallholder dairy farmers are encouraged to graze their stock privately in their homesteads (away from the mixed herds in communal rangelands) in order to avoid the extensive walking distances to grazing areas and watering holes that this system entails. The exotic dairy breeds are docile and therefore prone to bullying by the more aggressive beef type cattle. In intensive animal production systems, feed costs are generally acknowledged to make up anything ranging from 60% to 70% of total production costs. The ideal of the Swazi smallholder dairy production system is that each farmer should have at least one hectare of planted pasture per dairy cow. This ideal is hardly ever met, either because of land shortage or the lack of resources and skills to establish and maintain planted pastures (Ogwang, 1993;

Dlamini and Khumalo, 2000). The available land in the homesteads is primarily used for housing and crop production, both of which take precedence over fodder or pasture production. As a result there is a limited area of land available for cattle grazing and it is usually undeveloped, leaving the cattle to graze on naturally growing grass species. A few smallholder farmers have planted pastures, with the favoured species being Rhodes grass (*Chloris gayana*), Kikuyu (*Pennisetum clandestinum*), Italian Rye grass (*Lolium multiflorum*), *Paspalum notatum*, Star grass (*Cynodon dactylon*) and Elephant grass (*Pennisetum purpureum*).

Fodder crops are not commonly grown by most of the farmers and hence in the dry season the only abundantly available fodder resource is maize stover left over after grain harvesting. The stover is utilised in a number of ways; as is, chopped or chopped and mixed with urea and molasses. Hay is often sought from neighbouring commercial farms or imported from South Africa with the help of the MOAC and SDDDB who facilitate transport and scout for hay retailers. There are a number of potential feed ingredients locally available in the country, however, not all of them are readily available to smallholder farmers, either because the feed manufacturing companies and large-scale commercial farmers get first preference in purchasing them, or because the sources are very far from where the farmers reside and, hence, imply high transportation costs. These ingredients are often agro-industrial by-products such as molasses, bagasse, sugar cane tops, cottonseed, fruit canning waste (pulp or pellets), hominy chop, wheaten bran and spent brewer's grain (Taylor and Xaba, 1994). Hominy chop is the most abundant of these ingredients, since it is a by-product of milling maize into maize meal, and there are a lot of community based maize hammer mills in the rural areas (SNL). This hominy chop is often sold cheaper in the rural areas, however, the millers have begun to increase the prices in response to the increasing demand by farmers. In Kenya, Reynolds *et al.* (1996) reported that about 20% of farmers regularly purchase fodder and that other roughage sources commonly used include maize stover, banana stems and roadside grass (a generic term for natural pasture from a variety of sources).

The production systems employed by Kenyan smallholder farmers range from stall-fed cut-and-carry systems, supplemented with purchased concentrate feed in areas of high population density where extensive systems are not possible, to free grazing on unimproved natural pasture in the more marginal areas (Reynolds *et al.*, 1996). In Eritrea, Weldeselasia (2003) described a zero grazing production system in which the cattle are kept in barns and are stall-fed on forage and commercial dairy concentrate feed. The green forage supply reportedly consists mainly of green maize and/or barley at milk stage, spinach and other leafy vegetable wastes and limited quantities of Lucerne and Napier grass. In Asia, feed resources and nutrition constitute the principal technical constraints to ruminant production (Devendra and Sevilla, 2002). Rao and Hall (2003) reported that the mixed crop-livestock systems of India are underpinned by the crop residues, which contribute on average 40-60% of the total dry matter intake per livestock unit. In most instances, the efforts of smallholder dairy farmers to establish pastures and/or grow fodder crops are stifled primarily by the fact that they invariably have very small pieces of land and as a result their dry season milk yields are generally low and they have to rely on purchased forages for their cattle (Tambi, 1991; Mutukumira *et al.*, 1996; Hanyani-Mlambo *et al.*, 1998; Weldeselasia, 2003 and Lyimo *et al.*, 2004).

Commercial dairy concentrates are recommended for supplementary feeding to lactating cattle throughout the lactation period in order to meet their energy, protein and mineral requirements. There are three major animal feed manufacturing factories in Swaziland and they are all located in the industrial area in Matsapha, in the Manzini region and have distribution depots in the major towns and cities. Some independent retailers also sell imported commercial dairy concentrates from South Africa. Some ingredients used in the formulation of the feeds are obtained from within Swaziland and the majority imported from South Africa. The high cost of commercial dairy concentrates has led to most smallholder farmers either diluting the concentrate feed in an attempt to make it last longer or only feeding concentrates when they have the money to buy them. Weldeselasia (2003) reported

that in Eritrea, the smallholder farmers receive the dairy concentrate from the government run milk-processing plant in quantities commensurate to the amount of milk they supply for processing. The concentrate feed is commonly mixed with hominy chop on a 1:1 (volume) basis or mixed with hominy chop and molasses meal.

The dilution of the concentrate feed in essence deprives the cattle of the required nutrients, primarily the protein and to some extent energy. Given the desperate nature of the grazing situation, it follows, therefore, that milk yield would expectedly be negatively affected by the dilution since the dietary metabolisable energy and protein (ME and MP) are reduced by diluting the feed by what is primarily a source of fibre. The occasional feeding of concentrates according to resource availability is highly likely to result in reduced milk yields from the cattle, even at the most productive phases of lactation. In this situation, the potential for high milk yield after peak lactation would not be realised, since at this stage, the appetite of the animal is on the increase and the animal has already used up its body reserves for milk synthesis. Hence, the diet is required to provide sufficient protein and energy for maintenance, weight gain and milk synthesis. If these nutritional requirements are not met, the milk yield would be expected to decline more rapidly than normal and the cow would not improve in body condition, hence, it may have an extended postpartum anoestrus period. The prolonged postpartum anoestrus would then result in long calving intervals and either extended lactation periods (over 305 days) or extended dry periods.

1.8 Milk Collection and Marketing

The smallholder dairy farmers milk their cows by hand, mostly twice a day, under a shed or a milking parlour (accommodating one cow at a time) constructed from concrete blocks. The animals are normally coerced into milking by providing feed during the milking sessions. The milk is collected into buckets and is then strained of any foreign matter. The majority of smallholders do not have milk-cooling facilities and hence either have to sell their milk quickly or allow it to naturally ferment at room temperature into emasi. The fermentation results in a loss in volume since the whey is not sold but is strained and either fed to pigs and dogs or simply discarded. Most farmers sell the milk to their neighbours and those that have vehicles supply their customers in the urban areas with both fresh milk and emasi. In South Africa, Masiteng and van der Westhuizen (2001) reported that the smallholder farmers prefer to sell their milk in their neighbourhoods since the prices there are higher than when milk is sold to processors. In essence, an increase in production volume beyond the local consumption or demand compels the farmers to sell the excess milk to processing companies at far lower prices than they would have received in the informal market. Kaziboni *et al.* (2004) reported that during the rainy season, excess milk is discarded due to the lack of bulk cooling facilities in Nharira-Lancashire, Zimbabwe, which acts as a disincentive to producers and prospective farmers.

In an attempt to improve dairying, the Swazi government in the early 1990's solicited the help of the FAO in the preparation of a national dairy development plan. This included setting up two pilot smallholder milk producer and marketing groups, one in the Hhohho region and another in Mpaka. The Hhohho milk collection and marketing group (co-operative) is fully operational and consists of a bulk milk cooling tank, a marketing section for milk and emasi and a farm input store. The member farmers bring daily milk collections into the pool and each farmer's contribution is recorded, and when the milk is sold each farmer receives revenue according to his or her contribution. The formal fresh milk market prices (prices offered by milk processing companies) are still not favourable to producers and hence both

smallholder and large-scale commercial farmers are trying alternative means. The smallholder farmers prefer the informal market for retailing of dairy produce because of better prices, a phenomenon that appears to be generally common in Southern Africa (Mutukumira *et al.*, 1996; Hanyani-Mlambo *et al.*, 1998; Masiteng and van der Westhuizen, 2001). In Cameroon, Tambi (1991) reported that the low milk prices offered to producers' act as a disincentive for increased investment and production of milk to the farmers. In Swaziland, the commercial farmers are increasingly adopting the strategy of vertical integration, in which they practise processing (pasteurising fresh milk and producing emasi), packaging and distributing dairy produce to supermarkets and other retailers.

The objective of any farming enterprise is that the farmer makes a living from his or her produce, however the low fresh milk market prices have seen a lot of smallholder and large-scale commercial farmers leave the industry. The option of processing, packaging and distributing of dairy products is not an easy one for smallholder farmers primarily because of the small scale of their production set up and the fact that it requires a lot of capital and resources to which most have no access. The only option is to devise means that will make the milk collection schemes profitable and then increase their numbers across the country. In the areas where milk collection schemes (dairy co-operatives) have been established, the sparse distribution of the member farmers from the collection centre introduces a problem in the transportation of milk from each homestead to the centre, a problem duly noted by Hanyani-Mlambo *et al.* (1998) in Zimbabwe. In addition to the milk transportation problems, the farmers acknowledge (personal communication) that while selling their milk at the centre provides a steady substantial revenue, which they can reinvest into procurement of feeds and veterinary drugs, the price at which milk is sold at the centre is lower than that at which they sell it at their homesteads to their neighbours. As a result some farmers confessed to withholding some of their milk from the centre in order that they may make some more money from their home sales. The fluctuating milk production levels and inconsistent milk supply to the centre, makes smallholder farmers an unreliable supply source of milk to

processors and hence it is difficult for the SDDB and/or MOAC to organise a contract market for them with milk processing companies.

Farmer cooperatives, by virtue of their collective membership, provide the farmers with a vantage point in terms of economies of scale and their bargaining power (Morton and Miheso, 2000). They provide farmers with a reliable market for their daily milk produce as opposed to hawkers and individual customers, whose milk demand is erratic and is mostly influenced by the proximity of the farmer to the densely populated urban areas, with high demand for milk and dairy products in these areas (Hanyani-Mlambo *et al.*, 1998; Morton and Miheso, 2000). In Central Kenya, Morton and Miheso (2000) observed that farmers are prepared to accept lower milk prices from co-operatives than they would get elsewhere, if the package includes: monthly payment which allows budgeting for livestock and other expenses and a degree of short-term credit to allow access to feed and AI.

In spite of its problems, smallholder dairying remains a worthwhile venture for the development of rural communities and as a source of income and nutrition for many people in these rural communities. The onus is, however, upon farmers, SDDB and MOAC to create an environment in which smallholder dairying will become a viable business venture for farmers. The challenges to achieving this include adequate land allocation to farmers, training of farmers on dairy husbandry, pasture and fodder production, establishing more milk collection centres, provision or availability of affordable dairy animals, establishment of sound breeding programmes, efficient milk collection networks and markets that will bring in acceptable revenues to the producers. In essence, what has to be achieved is a more efficient system of smallholder milk production and marketing so as to minimise the production and marketing costs, while maximising the revenue.

1.9 Objectives Of The Study

The SDDB has long established that there is a disparity between the supply and demand of milk in Swaziland and, as such, the deficit has, and is, continually being made up for by importing a growing quantity of both liquid and powdered milk into the country. In Swaziland, there is no documentation of the quantity of milk produced by smallholder farmers and, hence, their contribution to the local milk market remains unknown. Furthermore, the potential of smallholder dairy producers and the constraints they face are not fully understood. The overall objective of this study was to assess the present situation of smallholder dairying in the country, with special focus on the Manzini region and surrounding areas. The specific objectives were:

- To better understand the dynamics of smallholder dairying in Swaziland.
- To identify and understand the main constraints on smallholder dairying and to hopefully devise workable solutions to these constraints.

Chapter II

Smallholder Dairy Production In Swaziland; Manzini Region & Surrounding Areas

Abstract

For years, milk production in Swaziland has been, and continues to be, less than the market demand. The quantitative contribution of smallholder dairy farmers to local milk production remains unknown because of poor record keeping. A sample of 118 smallholder dairy farms were covered in this study with total herd of 306 lactating cows, mainly Jerseys and Holstein Friesians with some cross breeds. There were no significant differences ($P > 0.05$) in mean milk yield/cow with respect to farmer gender and agro-ecological zone location of the farms. Milking frequency had a significant effect on milk yield since cattle milked once a day had lower ($P < 0.05$) milk yields than those milked twice a day. The cattle had extensively long calving intervals i.e. 448 ± 166 days, ranging from 292 to 1082 days. Low milk yield and poor reproductive performance of cattle were found to be mainly due to poor nutrition, breeding practices and stock quality. These are primarily a result of insufficient farmer training and inadequate technical assistance, scarcity of quality stock, lack of investment resources and market support with favourable milk prices for farmers to make money.

2.1 Introduction

The Swaziland milk production sector is made up primarily of a few large-scale commercial farmers (on TDL) and the numerous smallholder farmers on SNL. According to the SDDB, in the year 2002 there were 359 (86.51%) smallholder dairy farmers on SNL and 56 (13.49%) commercial dairy farmers on title deed land (TDL). Amongst the SNL farmers, some keep dairy animals solely for the purpose of feeding their families whereas others practise dairying in order to generate income and feed their families. The smallholder farmers normally have a few animals (1-20 cows) and use a low input type of production system. Land, labour and

capital are the scarce resources required for agricultural production. Land and capital scarcity have a huge negative impact on the production of smallholder dairy farmers.

Swazi smallholder dairy farmers are mainly made up of the following:

- 1) Working class individuals, who spend most of their time away from the dairy projects (i.e. at work) and either see them in the evenings or only on weekends, relying on either unemployed family members or hired staff to look after the animals in their absence.
- 2) Pensioners, who invest their gratuity and engage themselves in the dairy industry after their working life. Most of them do not have an idea of how demanding it is to run a dairy project and are neither mentally nor physically prepared to cope with the amount of work required of them on a daily basis. Consequently, they resort to hired hands to help and in most instances the projects eventually flop.
- 3) A small number of the farmers are self-employed people whose livelihood is solely dependent on farming, albeit they are involved in multiple agricultural enterprises (especially maize growing), which tend to take precedence over dairying. Some of these farmers are also involved in other non-agricultural enterprises.

On SNL, dairy animals are grazed within the farmers' homestead and are not commonly grazed in communal pastures in order to avoid indiscriminate breeding (ideally) and the extensive walking distances, which this entails. Consequently the farmer has to convert crop-growing fields within the homestead into pasture. The need for land to produce crops for human consumption always takes precedence over animal feed production, resulting in very small areas of land being allocated to pastures. Most smallholder dairy farmers have no planted pastures and therefore rely on the naturally occurring tropical grasses (natural veld), most of which are lower in nutritional value than the temperate species. During the dry season the grass senesces quickly, which leads to lignification and a decline in crude protein

content (Roothaert, 2000). The result is then a decline in animal productivity and a loss of body condition.

Animal nutrition is one of the main constraints faced by the smallholder farmers since they totally rely on naturally growing grass on limited pieces of land for feeding dairy cows. They do not grow fodder crops save for the maize stover remaining after grain harvesting. As a result they have to buy hay and other fodder types to supplement animals in the dry season and these are not only scarce but also expensive. The commercial dairy concentrates are also costly, with most farmers having to incur the extra costs of transporting the feed to their distant homesteads.

Capital resources for investment in the dairy projects in the form of loans are not forthcoming since the financial institutions normally require the borrower to put forth some form of collateral before the loan can be granted. Farmers on SNL do not own the land that they use for production and, hence, cannot use it as surety for loan repayment. Another problem is that the financial institutions require some form of a business plan, which entails a cash flow budget and since most of these farmers do not keep any production records it is difficult for them to receive the help they require.

Most of the milk produced by these farmers is sold in the informal market at a more favourable price than that offered by the commercial milk processing companies. The amount of milk they produce can, therefore, not be quantified since only a few of them keep production records. The problem, however, with the informal market is its seasonal and inconsistent demand for milk, as it is high in the dry season and low in the wet season. The reason being that in summer there is an abundance of food from the previous year's harvest and most consumers change their diets to vegetables and herbs, which are abundant and mostly free growing at this time of the year as opposed to the winter when they are minimal.

The objectives of this study were to define and understand the smallholder dairy production sector in Swaziland, outlining production constraints faced by the farmers and possibly to propose solutions that could help improve milk production by smallholder dairy farmers.

2.2 Materials & methods

Swaziland is located in the south-eastern part of Africa between latitudes 25°30' and 27°30'S and longitude 30°45' and 32°07'E. It is almost entirely surrounded by South Africa save for the eastern portion bordering Mozambique. The country has four major agro-ecological zones; namely the Highveld, Middleveld, Lowveld, and the Lubombo plateau. In terms of physiography, the Middleveld and Lowveld both contain two distinct zones i.e. upper and lower middleveld (separated by altitude and geology) and eastern and western Lowveld (separated by geology) (Sweet and Khumalo, 1994). Swaziland therefore has six agro-ecological zones when physiography is taken into consideration. The characteristics of the agro-ecological zones are shown and discussed in chapter1 (Table 1.1).

A total of 118 randomly selected smallholder dairy farms, mostly on SNL from the Manzini region were used as data collection stations. Some of the farmers in the study were affiliated to dairy co-operative societies. The Manzini region was chosen for the study because it has the highest number of smallholder dairy farmers (SDDB, 2002). Manzini was the logical choice, given the limitations of time and resources at the time of conducting the study and in addition it is the hub of the country. The information on farmer location was obtained from the dairy extension records of the Ministry of Agriculture and that of the Dairy Development Board. The Manzini region spans over three agro-ecological zones, namely the highveld, upper middleveld and the lower middleveld. The smallholder dairy farms used in this study are by location randomly distributed amongst these three agro-ecological zones.

Data collection was done between November 2003 and March 2004 by means of a questionnaire, which was filled in by the researcher upon orally interviewing the farmers and herdsman. The farm visits were timed to coincide with the early morning milking time of most farmers. Observations of the handling and management of the dairy animals were objectively noted from a technical perspective on each farm as the farmers went about their daily milking and feeding routines on the farms. The collected data include visit (test) day milk yields, breeding and reproductive performance records, feeding strategies, milk marketing and constraints on smallholder dairying. The cattle in this study were at different stages of lactation, age groups and parity. Due to poor record keeping, detailed breeding data was obtained only from a few elite record-keeping farmers.

Data analyses of variance (ANOVA) were conducted on GenStat 6th edition (2002) and descriptive statistical analysis was performed on SAS (2002).

2.3 Results & Discussion

Of the 118 farms, the majority of owners (81.36%) were male and the female farmers were the minority (18.64%). This is, however, not entirely a true reflection of the actual situation since most female farmers could have registered their dairy projects in the names of their husbands even when the husbands aren't actively involved in dairying. This is in conformity to the old Swazi custom and tradition which hands ownership of any major projects or family assets to the head of the family. The distribution of the farms by location was such that 50.0%, 32.3% and 17.8% of the respondents originated from the upper middleveld, the highveld and the lower middleveld, respectively.

The Manzini region is the hub of Swaziland and the upper middleveld almost invariably cuts through the centre of the country. This part of the country is fairly well developed in terms of infrastructure, is nearer to town and the industrial area (milk market availability) as well as to

feed mills and other farm input retailers. It is however, more densely populated and hence there is less land available for grazing cattle in the available SNL.

The lower middleveld is more distant from major towns, industrial areas, feed mills as well as farm input retailers. It is drier (receives less annual rainfall) than the upper middleveld and highveld. The highveld receives the most annual rainfall and is much cooler than the middleveld, however, most of the farms here are distant from major towns, feed mills and other farm input retailers. The grazing land availability problem, however, is inherent in all agro ecological zones of the country on SNL, with the exception of a few farmers.

2.3.1 Herd Structure And Breed Composition

The total herd of cattle (from 118 farmers) consisted of 306 lactating cows, 85 dry cows, 128 heifers, 248 calves, 41 bullocks and 33 bulls as shown in Table 2.1. The population of lactating cows in comparison with the number of farmers is very low, giving a mean of 2.6 (3) cows per farmer. The calves were notably fewer than lactating cows, which raises questions about the fertility of the cows, the breeding systems, general animal health, nutrition and possibly the calf rearing skills of some of the farmers.

The commonly kept breed of dairy cattle amongst the smallholder farmers is the Jersey, followed by the Holstein Friesian and their crosses. A very limited number of farmers also keep Ayrshire, Guernsey and Brown Swiss breeds. This fact is clearly emphasized by the breed distribution in Table 2.2. As noted in Table 2.2, most farmers had a variable mix of pure breeds and crosses that were used for dairying.

Table 2.1: Breakdown of the total herd used in the study.

| Variable | Sum | N | Mean | Std Error | Min. | Max. |
|--------------------------|--------|-----|------|-----------|------|-------|
| Lactating cows | 306.0 | 118 | 2.6 | 0.23 | 0 | 14.0 |
| Dry cows | 85.0 | 118 | 0.7 | 0.11 | 0 | 8.0 |
| Total cows | 391.0 | 118 | 3.3 | 0.29 | 0 | 20.0 |
| Calves | 248.0 | 118 | 2.1 | 0.23 | 0 | 16.0 |
| Heifers | 128.0 | 118 | 1.1 | 0.14 | 0 | 9.0 |
| Bullocks | 41.0 | 118 | 0.3 | 0.08 | 0 | 6.0 |
| Bulls | 33.0 | 118 | 0.3 | 0.04 | 0 | 2.0 |
| Mean yield (ℓ) | 2319.5 | 114 | 20.3 | 2.31 | 0 | 156.0 |
| Milk efficiency/ cow (ℓ) | 840.5 | 100 | 8.4 | 0.41 | 2.0 | 25.0 |
| Meff1 (ℓ) | 750.1 | 113 | 6.6 | 0.44 | 0 | 25.0 |

N = number of farms; Minimum & Max, indicate the ranges in observations per variable in the sample population. Milking efficiency/cow = milk yield of lactating cows only (litres/cow). Meff1 = milking efficiency (litres) for all cows, including dry cows.

Table 2.2: Breed distribution in smallholder dairy farms.

| Breed index | Farm Frequency | Percentage |
|---------------|----------------|------------|
| A | 1 | 0.85 |
| B, J, HFx | 1 | 0.85 |
| G | 1 | 0.85 |
| HF | 11 | 9.32 |
| HF, B | 1 | 0.85 |
| HF, Jx | 1 | 0.85 |
| HFx | 12 | 10.17 |
| I, Jx | 1 | 0.85 |
| J | 40 | 33.90 |
| J, Bx | 1 | 0.85 |
| J, HF | 16 | 13.56 |
| J, HF, B | 1 | 0.85 |
| J, HF, J x HF | 1 | 0.85 |
| J, HFx | 11 | 9.32 |
| J, Jx | 2 | 1.69 |
| Jx | 14 | 11.86 |
| Jx, HFx | 2 | 1.69 |
| J x HF | 1 | 0.85 |

A – Ayrshire, **B** – Brown Swiss, **G** – Guernsey, **HF**- Holstein Friesian, **J** – Jersey, **I** – Indigenous breed, **HFx** – Holstein Friesian cross breed, **Jx**- Jersey cross breed, **Bx** - Brown Swiss cross breed, **J x HF**– Jersey x Holstein Friesian cross breed

The Jersey is the most predominant breed, found in 33.9% of the farms as the sole breed. It is the most favoured breed because of its hardiness and low maintenance requirements in addition to the high butterfat content of its milk. The Holstein Friesian breed was found in 9.32% of the farms as the sole breed. Most farmers shy away from this breed because it is more expensive, less hardy and has higher maintenance requirements compared to the Jersey. It is, however, a very high milk yielding breed and hence 13.56% of the farmers kept it in combination with the Jersey breed in an attempt to balance the high milk yield with the high butter fat content of the Jersey milk. The Ayrshire, Brown Swiss and Guernsey are the least kept breeds, primarily because of their low popularity and poor stock availability in Swaziland.

A major factor that contributes to the breed orientation of the Swazi smallholder dairy industry is that stock acquisition (importation), normally conducted by the SDDB in collaboration with the MOAC, mainly focuses on Holstein Friesian and Jersey cows (the abundantly available breeds) from South Africa. An additional factor is that these are the breeds that the farmers also know and trust.

The poor breeding programmes employed in most of these farms coupled with the desire to have low maintenance dairy animals (to conform to the low input production system often practised by smallholder farmers) have resulted in a number of farmers cross breeding the exotic dairy breeds with indigenous and other tropical breeds such as the Nguni, Brahman and others. The offspring of these crosses is then used as replacement stock for their enterprises or sold to other aspiring dairy farmers.

The F1 resulting from this out crossing are much hardier than their exotic parental generation but do, however, lose the high milk yielding genetic potential possessed by the pure dairy breeds. If this cross breeding were done strategically, the F1 females would certainly give higher milk yields under good management than the indigenous breeds. The challenge,

however, is that this newly formed crossbreed (F1) could not easily be reproduced en masse without reducing genetic variation in the F2 generation. The loss of genetic variation would therefore mean the loss of hybrid vigour, hence, milk yield would likely decrease. A simplistic solution to this problem is that there would have to be a government-run breeding facility to constantly supply the farmers with the F1 (crossbreed) heifers as replacement stock. The farmers would have to exchange their male calves or cash at government revenue offices for the F1 replacement heifers at an annually revised predetermined cost recovery rate.

The application of such a breeding programme might not be financially viable since it would require that a breeding facility with a large stud herd be maintained for the production of the F1 crossbreed. Such a project was at some time attempted by the Swazi government during which Brahmans were bred with the exotic dairy breeds in government farms. The F1 crosses were then sold to farmers for milk production, however, these animals were then indiscriminately back-crossed by farmers with other non-dairy breeds, including the indigenous Nguni and hence the F2 and F3 generations lost their high milk yielding genetic potential. The Swazi government already has an established dairy farm, whose main purpose is to train farmers in dairy husbandry as well as provide replacement stock at cost (below free market prices) to smallholder farmers. One solution would therefore be for government to restore this farm to its full operational capacity in order to facilitate a more efficient AI-based breeding programme of the Holstein-Friesian and Jersey breeds to meet the already existing high demand for these breeds. This would ensure that the farmers receive replacement stock of high genetic quality and increase milk yields. The AI service provision programme, currently run by SDDB, and in which, some key farmers in the communities are trained to be inseminators, would complement this programme.

2.3.2 Breeding

Table 2.3: Reproductive performance measures from farmers who kept records.

| | n | Mean | SD | Range |
|---|----------|-------------|-----------|--------------|
| Gestation Period | 57 | 278.6 | 6.99 | 256 - 293 |
| Calving Interval | 28 | 453.9 | 165.68 | 319 -1082 |
| Interval from calving to re-conception | 35 | 154.3 | 117.53 | 38 - 461 |
| No. Services to Conception | 29 | 1.6 | 0.81 | 1.00 - 3.00 |

n = sample sizes; the above reproductive performance data is given in days

The mean gestation period in this study was 279 ± 7.0 days (Table 2.3). This is within the range observed by previous researchers (King *et al.*, 1982; Stewart, 1995; Bearden and Fuquay, 2000). Gestation length varies according to individual animals, breeds, embryo sex, parity and age of the dam (King *et al.*, 1982). The mean interval from calving to first oestrus or service for these herds could not be obtained because of recording irregularities; instead the intervals from calving to the last service before conception were obtained (± 154 days). The observed mean calving interval was 448 ± 166 days, ranging between 319 to 1082 days. This mean calving interval (14 months) is greater than the recommended 12 to 13 months (Louca and Legates, 1968; Butler and Smith, 1989; Stewart, 1995). The herd in this study had a mean of 1.6 apparent services per conception, which is reasonably acceptable, hence, bringing to question the period of uterine involution, resumption of ovarian activity of the cattle and heat detection by farmers.

The very long inter-calving periods could be due to extended breeding periods; partly a consequence of poor heat detection, pathological anoestrous and nutrition. Of the 118 farmers, only 40.7% (48) had received some form of training on heat detection but 59.3% (70) admittedly had not. Only 25 farmers were strictly practising artificial insemination (AI) as their sole breeding system and of these, only one farmer had not been trained in heat detection. Thirteen farmers used both bulls and AI for breeding. Amongst these, 7 had been trained in heat spotting and the other 6 had not. Of the 13, only two of these farmers owned bulls that they used for breeding while the other 11 had to rely on their neighbour's bulls,

which were not necessarily dairy breeds. Eighty farmers (67.8%) of the 118 only used bulls exclusively for breeding and only 38 (47.5%) of these farmers actually owned the bulls. The remainder relied on neighbouring dairy farmers to lend them bulls when their cows overtly manifested heat (standing heat). It is, however, not always possible to get the bull at the required time, hence, the cows are not serviced at times or are then covered by non-dairy bulls (beef &/or dual purpose breeds). The unfortunate outcome, however, is that the cows either have extensively long inter-calving periods and/or the offspring resulting from this unplanned crossbreeding are used as replacement stock (Table 2.2). Whilst interested farmers should be provided with training on pertinent aspects of dairy husbandry, they should be encouraged to use bulls either singly or as a group. The use of AI would, however, eliminate the extra responsibility of managing and feeding a bull, simultaneously ensuring the introduction of good genotypes and genetic variation in the herds. The logistics of the AI programme, currently in use need to be reviewed to enable efficient service provision.

The pre and postpartum condition of the cows and their management (husbandry and physical environment) have a bearing on their physiology, hence, poor management could be the cause of poor reproductive performance (delayed uterine involution and resumption of ovarian activity). Gier and Marion (1968) reported that the shrinkage of the vascular system and muscular contractions continued to reduce the size of the post-gravid bovine uterus until it reached a near pregravid size by 40 to 50 days postpartum. Puerperal condition exerts the most noticeably widespread influence on both the ovarian activity and uterine involution in postpartum cows, while the level of total digestible nutrients (TDN) plays an important role in the resumption of ovarian activity (El-Din. Zain *et al.*, 1995). Dams without puerperal complications ovulated earlier (at 22 days) than those encountering puerperal complications (≥ 31 days) (El-Din. Zain *et al.*, 1995). Puerperal disorders (retained foetal membranes, parturient paresis, reproductive system infections and ovarian cysts) were found to have detrimental effects on the calving to first oestrus interval, calving to first service interval,

calving to conception interval, calving interval, services per conception and conception rate at first service (Scheidegger *et al.*, 1993; Risco *et al.*, 1994). Negative energy balance (NEBAL) primarily appears to interfere with the ability of the hypothalamo-hypophyseal axis to develop the pulsatile luteinising hormone (LH) pattern necessary for fostering ovarian follicular development and ovulation (Butler and Smith, 1989). The NEBAL is related to lower fertility (longer postpartum anovulatory period) in dairy cows both through effects exerted in early lactation and later during the breeding period (Butler, 2003).

The observed postpartum voluntary waiting period is extensive, given that the interval from calving to the last service before conception was ± 154 days, with an average of 1.6 services to conception. The recommended rebreeding time is on the first oestrus occurring after 45-60 (Stewart, 1995) or 60 days postpartum (Foote, 1978). This voluntary waiting period before breeding accommodates complete uterine involution and the resumption of normal cyclic ovarian activity of the postpartum cows, both of which are essential for normal reconception and gestation. Once initiated, cyclic ovarian activity in postpartum dairy cows seems to continue regularly, hence the re-establishment of ovulatory cycles early after parturition assures multiple oestrus cycles prior to the recommended breeding period and therefore has a positive influence on conception rates (Butler and Smith, 1989).

2.3.3 Milking Management

All the smallholder farmers practise hand milking and the cows are often milked in a shed or open space. During the milking session, the cows are invariably fed to ensure their compliance to being milked. Feeding is either on a fixed scale across the herd or for the duration of the milking session. The cows are fed on a variety of feeds ranging between commercial dairy concentrate, hominy chop, crushed yellow maize, dairy concentrate mixed with hominy chop and other home made rations. The cattle voluntarily approach the milking parlour or shed around the expected milking time, perhaps in anticipation of the feed they will

receive during milking hence they experience no trauma prior to and during the milking sessions. There are, however, varying levels of hygiene practised with respect to udder and teat cleaning, cleanliness of the milker and the equipment used. Consequently, it is unlikely that milk let down is negatively affected by management practices during milking. Examples of some management practices are attached in annex 1.

Table 2.4: Daily milk yield statistics according to the different breed combinations in the different dairy herds.

| Breed index | Sum Milk Yield (ℓ) | Rep | Mean Milk Yield (ℓ) | SE Milk Yield | Min Milk Yield (ℓ) | Max Milk Yield (ℓ) |
|-------------|--------------------|-----|---------------------|---------------|--------------------|--------------------|
| A | 13.0 | 1 | 13.0 | . | 13.0 | 13.0 |
| B, J, HFx | 3.6 | 1 | 3.6 | . | 3.6 | 3.6 |
| G | 22.0 | 1 | 22.0 | . | 22.0 | 22.0 |
| HF | 59.2 | 8 | 7.4 | 1.43 | 4.0 | 15.0 |
| HF, B | 10.0 | 1 | 10.0 | . | 10.0 | 10.0 |
| HF, Jx | 3.3 | 1 | 3.3 | . | 3.3 | 3.3 |
| HFx | 82.0 | 10 | 8.2 | 0.96 | 5.0 | 15.0 |
| I, Jx | 3.6 | 1 | 3.6 | . | 3.6 | 3.6 |
| J | 317.5 | 36 | 8.8 | 0.69 | 2.0 | 25.0 |
| J, Bx | 10.0 | 1 | 10.0 | . | 10.0 | 10.0 |
| J, HF | 128.8 | 14 | 9.2 | 1.07 | 2.5 | 18.8 |
| J, HF, B | 12.5 | 1 | 12.5 | . | 12.5 | 12.5 |
| J, HFx | 62.4 | 9 | 6.9 | 1.01 | 2.5 | 10.0 |
| J, Jx | 23.4 | 2 | 11.7 | 0.80 | 10.9 | 12.5 |
| Jx | 83.1 | 12 | 6.9 | 1.16 | 2.0 | 15.0 |
| Jx, HFx | 6.0 | 1 | 6.0 | . | 6.0 | 6.0 |

A – Ayrshire, **B** – Brown Swiss, **G** – Guernsey, **HF**- Holstein Friesian, **J** – Jersey, **I** – Indigenous breed, **HFx** – Holstein Friesian cross breed, **Jx** - Jersey cross breed, **Bx** - Brown Swiss cross breed,

Table 2.5: Proportions of lactating cows according to herd breed composition and farms.

| Breed Index | Sum of Lactating Cows | Rep | Mean Lactating Cows | SE Lactating Cows | Min # Lac Cows | Max # Lac Cows |
|-------------|-----------------------|-----|---------------------|-------------------|----------------|----------------|
| A | 1 | 1 | 1.0 | . | 1 | 1 |
| B, J, HFx | 14 | 1 | 14.0 | . | 14 | 14 |
| G | 1 | 1 | 1.0 | . | 1 | 1 |
| HF | 16 | 11 | 1.5 | 0.53 | 0 | 6 |
| HF, B | 2 | 1 | 2.0 | . | 2 | 2 |
| HF, Jx | 3 | 1 | 3.0 | . | 3 | 3 |
| HFx | 17 | 12 | 1.4 | 0.29 | 0 | 4 |
| I, Jx | 7 | 1 | 7.0 | . | 7 | 7 |
| J | 100 | 40 | 2.5 | 0.39 | 0 | 14 |
| J, Bx | 4 | 1 | 4.0 | . | 4 | 4 |
| J, HF | 53 | 16 | 3.3 | 0.55 | 0 | 8 |
| J, HF, B | 2 | 1 | 2.0 | . | 2 | 2 |
| J, HFx | 27 | 11 | 2.5 | 0.65 | 0 | 7 |
| J, Jx | 13 | 2 | 6.5 | 4.50 | 2 | 11 |
| Jx | 38 | 14 | 2.7 | 0.60 | 0 | 8 |
| Jx, HFx | 8 | 2 | 4.0 | 1.00 | 3 | 5 |

A – Ayrshire, B – Brown Swiss, G – Guernsey, HF- Holstein Friesian, J – Jersey, I – Indigenous breed, HFx – Holstein Friesian cross breed, Jx- Jersey cross breed, Bx- Brown Swiss cross breed,

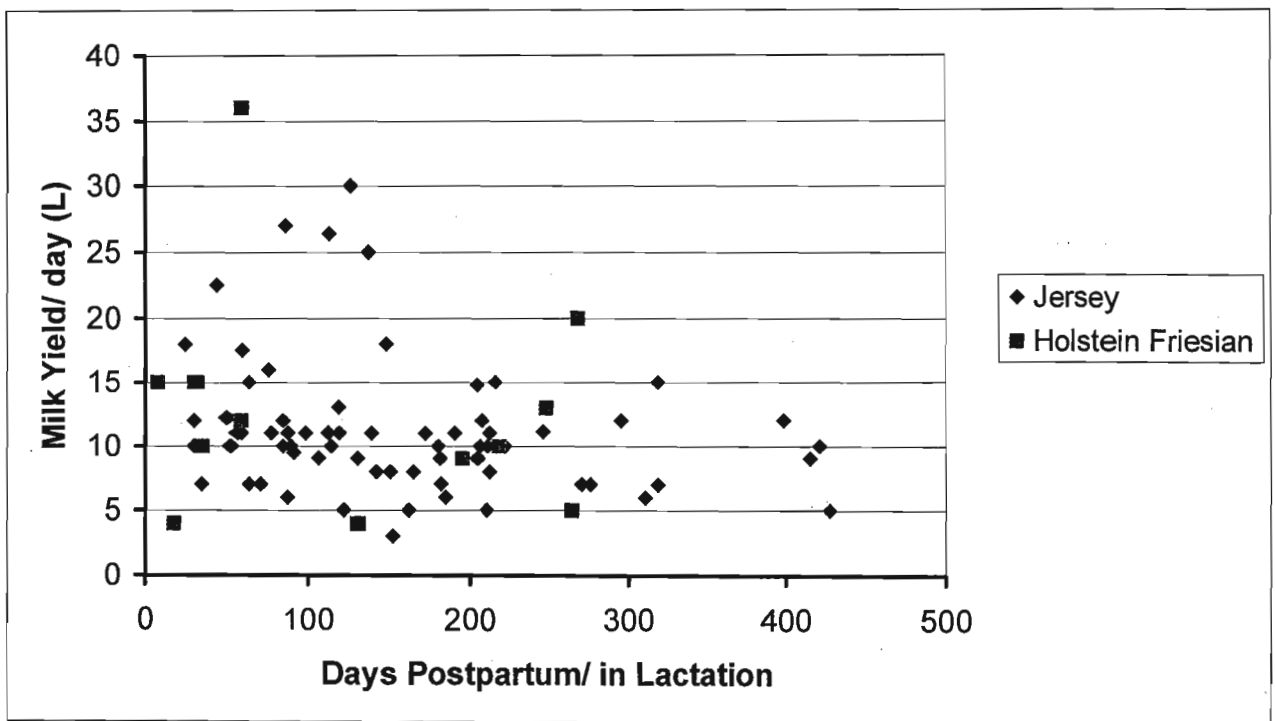


Figure 2.1: Milk yield comparison between breeds at different stages of lactation obtained from various herds of record keeping farmers.

The frequency of milking per day ranged between once daily to twice a day amongst the smallholder farmers at the time the study was conducted. Most farmers (77.12%) milked their cows twice a day, while the rest (22.88%) practised once daily milking (usually in the morning), with the exception of those cows that were being dried off at the time. The farmers that practised twice a day milking were exclusively those that kept milk yield records. On the farms where cows were milked once a day, the mean milk yield/cow/day was 5.6 ± 2.85 litres and where milking was done twice a day, the yield was 9.1 ± 4.08 litres. Cows milked twice a day had a significantly higher ($P < 0.05$) mean milk yield/cow/day than those milked once daily. This is in agreement with reports of increased milk yields with increased milking frequency (Prosser and Davis, 1992; Bar-Peled *et al.*, 1995), without an increase in dry matter consumption throughout the entire lactation period, regardless of parity (DePeters *et al.*, 1985). In the same manner, cows milked 3 times a day had higher milk yields and lactation persistency compared to those milked twice a day over a 305 day lactation period, regardless of parity (Amos *et al.*, 1985).

Milking frequency is known to positively influence milk yield in that it encourages secretion in the mammary gland by milk removal from the teat cistern and also helps in the maintenance of lactation (galactopoiesis). Under good nutrition and breeding management, the majority of the cattle should have reasonably high milk yields and long lactation periods (305 days per year). A number of farmers however reported that some of their cows had about half or less than half the length of the expected lactation periods (milk yields were so low that it was no longer worth milking the cows). An unknown proportion of the cows milked once a day were being dried off in preparation for calving, while the rest had either exceeded a year without calving due to re-breeding problems or were yielding low amounts of milk as a result of poor management or both.

A large number of the farmers (77.97%) did not keep milk yield records and of the 22.03% that kept records, some only noted the total milk yield per milking session and others, total milk yield per day (not the individual milk yield per cow per milking or per day). Since some farmers kept daily milk yield records per cow and some did not, to accommodate the farmers that had no records, the present day's milk yields were requested (test day milk yields) since they could still be remembered. The mean milk yield/cow/day among the farmers that kept milk yield records was 9.5 ± 4.39 litres and that from non-record keeping farmers was 8.1 ± 3.99 litres, with no significant difference ($P > 0.05$) between them. The non-record keeping farmers consisted of both those farmers that practise once daily and twice daily milking.

The mean milk yield/cow/day amongst male farmers was 8.6 ± 4.17 litres and that for female farmers was 7.5 ± 3.67 litres. The male farmers appeared to have a slightly higher daily mean milk yield (1litre) per cow than female farmers. This difference is, however, not significant ($P > 0.05$). Agro-ecological zone location of farmers had no significant effect ($P > 0.05$) on milk yield, with mean milk yields/cow/day of 8.1 ± 4.69 , 8.4 ± 3.81 and 8.8 ± 4.12 litres for the Highveld, Upper Middleveld and Lower Middleveld, respectively.

2.3.4 Pastures and Fodder

Only 19 (16.1%) of the respondents in this study had some patch of planted pasture, no greater than 100m^2 each in size (estimate). The remaining 99 farmers (83.9%) had no planted pastures and were totally reliant on naturally growing tropical grass species for grazing dairy cows. The grass species commonly planted include Rhodes grass (*Chloris gayana*), Kikuyu (*Pennisetum clandestinum*), Italian Rye grass (*Lolium multiflorum*), *Paspalum notatum*, Star grass (*Cynodon dactylon*) and Elephant grass (*Pennisetum purpureum*).

The average available grazing area for cattle in 100 of the homesteads was 2.5 hectares, ranging from ≤ 0.5 Ha to about 8 Ha (estimated area). One group (of five farmers) was practising a group ranching system in which their animals were exclusively sharing about 15 hectares of rangeland. Thirteen farmers depended entirely on communal grazing and hence had to drive their animals over a considerable distance to graze in mixed herds with other livestock on a daily basis. The available grazing area in this regard is unknown and the grass species herein are diverse, naturally growing species with a general predominance of *Sporobolus* and *Hyparrhenia* species (general observation).

The observed poor grazing and absence of planted pastures agrees with the findings of Dlamini and Khumalo, (2000) and Ogwang (1993). Pastures are the cheapest source of feed for dairy cows and the most efficient feed source when supplemented with commercial dairy concentrates. There is generally a problem of land availability, which, when coupled with the fact that whatever available land is primarily used for crop production, results in even less land available for cattle grazing.

The reliance on naturally growing tropical grasses means that the cattle only have good grazing in spring and early summer when new, highly nutritious grass shoots emerge as a result of the early rains and organic nitrogen release in the soil. The limited pasture sizes, however, mean that there is insufficient grass for cattle to graze on and therefore introduces a danger of overgrazing of the available pasture resource. If the grazing requirements of the cattle are not met, the cattle lose condition and productivity in terms milk yield, growth and reproduction. Under these conditions the supplementary feeding of concentrates by farmers becomes inefficient since they are merely substituting grass with a more expensive feed. In the dry season, the tropical grasses senesce and lignify, losing nutritional value. During this season the cattle have even less to graze on and hence require some form of supplementary feeding.

Fodder provision in the dry season was found to be one of the greatest challenges faced by the smallholder dairy farmers. Eighty-eight farmers (74.6%) claimed to provide hay in the dry season and of these only a few had actually grown the fodder themselves. The hay is often purchased from commercial farmers and mostly imported from South Africa with the help of the MOAC and SDDB. There were only 7 (5.9%) farms in which some form of silage was fed to cattle in the dry season. Most smallholder farmers, however, do not grow any fodder crops or hay and as a result some stop milking when milk yield dwindles. Only those who can afford to purchase hay and other fodder types, supplemented with commercial dairy concentrates are able to maintain good milk yields. The extensive walking distances covered by the communally grazing cows increases the daily energy requirements and impacts negatively on milk yield (Coulon *et al.*, 1998). Dietary energy intake is insufficient due to poor grazing conditions and nutritional quality of the grazing, and this is exacerbated by extensive walking to find grazing since the cattle can not increase their dry matter intake enough to meet their energy needs for production (Coulon and Rémond, 1991; Matthewman *et al.*, 1993; Coulon *et al.*, 1998).

As with previous studies (Dlamini, 1990; Ogwang, 1993; Dlamini and Khumalo, 2000) it was established that the major constraints to pasture development and fodder conservation were lack of finances, skills, knowledge, equipment, land and in some instances water availability. This can partly be mitigated by the planting of winter pastures and fodder crops on croplands after harvest, since these fields are usually left to lie fallow until the next cropping season. A major drawback to this suggestion would be the need for irrigation in the dry season when water resources, capital, skills and equipment are lacking. In the dry season there is an abundance of maize stover, remaining after grain harvesting and most farmers allow the cattle to feed on the stover from the fields while some feed it from stalls as is. A few farmers cut it up into bits and add molasses to increase its palatability. Chopping up the stover and adding some urea and molasses would increase its intake, milk yields and body condition throughout the dry season.

2.3.5 Milk Yield

The majority of cows shown in Fig. 2.1 that are within the first two hundred days of their lactation are clustered around 10 litres per day (milk yield) with the exception of only a few. Considering that these are dairy animals at the productive stage of their lactations, they would be expected to have higher milk yields than what was observed. The low milk yields could be explained by the fact that some cows are of poor genetic value in terms of milk yield or that some are genetically sound animals under poor management. In this case both factors could apply because some of the cattle have been out crossed with non-dairy breeds and have hence lost their genetic merit for high milk yields. Some of the cows (pure dairy breeds) have a genetic potential for high milk yields but cannot perform to their capacity because they are under poor management.

Peak milk yield in the ruminant animal is attained relatively early during lactation, and this is followed by a progressive decline so that at the time of "drying off" yield may be reduced by 50% of the maximum value (Wilde and Knight, 1989). In this study there are, in some cases instances where farmers extended the lactation period beyond 305 days as shown in Fig. 2.1. These cows under extended lactation are either in calf or open, as suggested by the long calving intervals (Table 2.3). For optimal production, cattle require a dry period of 40-60 days (Swanson, 1965; Coppock *et al.*, 1974; Sørensen and Enevoldsen, 1991; Capuco and Akers, 1999) and if the dry period either is too short or too long, subsequent milk yield is reduced (Tucker, 1987). The dry period permits the replacement of damaged or senescent epithelial cells prior to the ensuing lactation in addition to mammogenesis (Capuco *et al.*, 1997). In the course of data collection it was gathered that most farmers, especially those breeding using bulls had no idea of the stage of gestation of their animals and hence some were being milked until parturition. This means that the cattle either had very short dry periods or none at all. On the other hand, some of the cows were open (extensively long calving intervals) during their extended lactation period.

Milk yield is determined by secretory epithelial cell numbers and by the secretory activity per cell (Forsyth, 1986) and the decline in milk yield after peak lactation is due to a decrease in the number of secretory cells (Wilde and Knight, 1989; Wilde *et al.*, 1999). Continual milking extends the lactation period by providing a lactation stimulus that maintains the declining milk production by somewhat delaying secretory cell loss (Wilde and Knight, 1989) even in the absence of pregnancy. In the recommended dairy practice, there is a significant overlap of lactation and pregnancy such that the cattle are in late gestation during the drying off period therefore when milk stasis occurs, the mammogenic and lactogenic stimulation of pregnancy opposes stimuli for mammary involution (Capuco and Akers, 1999). During pregnancy, there is a substantial increase in numbers of epithelial cells in the mammary gland. Mammary epithelial cells also complete their differentiation during pregnancy (Forsyth, 1986). There is a cascade of hormones responsible for the initiation and maintenance of lactation and pregnancy is the greatest physiological stimulus for milk yield (Tucker, 2000).

2.3.6 Milk Marketing and Economics

Bergevoet *et al.* (2004) reported that there is a significant relationship between farmer behaviour and their goals and intentions. In addition to their love for animals, most smallholder dairy farmers in this study aim to make money and provide food for their families. To make a profit, the revenue received from milk sales should exceed the total cost of inputs and therefore farmers need to sell their milk at favourable prices. Dairy prices were deregulated in October 1999 in Swaziland (SDDDB, 2000); hence, the market forces of demand and supply currently determine prices. The formal market (major liquid milk processing company) offers farmers E2/litre of milk while in the informal market they are able to sell milk between E3 to E7 per litre (E1 = R1). In a bid to promote smallholder dairy production (FAO, 1998), milk collection centres were established in strategic dairy communities by SDDDB in conjunction with MOAC. In adherence to the dairy development

plan, it would be expected that more milk collection centres are yet to be established throughout Swaziland.

One prerequisite is the formation of a legally recognised co-operative organisation or company by the dairy farmers, the objective being to pool their daily milk harvest at the centre, which is then either collected by the milk processing company once every two to three days or marketed from the collection centre as fresh milk or emasi (sour milk). The major drawbacks to this developmental strategy, however, are two fold;

1. The farmers are often scattered over extensive distances from each other and from the collection centres, presenting a problem of transporting milk while still fresh from the homesteads to the centre, twice daily.
2. The other problem is that the farmer groups need to acquire capital, through loans in order to invest in the needed facilities. The absence of group owned assets to be used as collateral limits the chances of receiving loans from financial institutions. Even when funds or opportunities are available for dairy development, the problem of loan repayment remains since there is always a fluctuation in the number of co-operative members because some pioneering members leave the industry for various reasons and new ones come in.

Two of the three farmer community groups with bulk milk coolers in the country were covered in this study. When interviewed, some farmers admitted to withholding some of their milk from the pooled marketing to the formal market because of the low revenue received. This milk is then sold from their homesteads or delivered to specific customers in the vicinity. In most communities there are no formal dairy farmer groups and milk collection centres, therefore milk is sold from the homesteads, delivered to teachers and nurses in nearby schools and clinics or delivered to city dwelling customers in buckets by those farmers with

vehicles on their way to work. Since the informal market demand is inconsistent and the farmers have no milk cooling facilities, they are compelled to naturally ferment the remaining milk at room temperature and sell the sour milk (emasi). The milk is fermented in specially designed plastic buckets with whey draining taps at the bottom and this results in the loss of about half the volume of the collected fresh milk (to whey) and hence the loss of potential income even though the sour milk (emasi) is sometimes sold at about twice the price of fresh milk.

It was gathered (in the Mayiwane area) that the pooled milk marketing is beneficial to the farmers in some ways. Records of each farmer's contribution are made on a daily basis and when the milk is sold, the money is allocated according to the quantity contributed. This ensures that they are now able to receive substantial weekly revenue as opposed to the small daily collections made at home, which invariably end up being used for other household needs instead of being reinvested into the dairy projects. The weekly revenue now enables the farmers to purchase farm inputs such as dairy concentrate feed, dipping chemicals (acaricides), veterinary pharmaceuticals, grass seeds etc. Consistent availability of production inputs in addition to good management practices can result in improved animal performance in terms of milk yields, reproduction, growth and condition.

A number of commercial dairy farmers have adopted the strategy of on farm milk processing, packaging and distribution to the major supermarket chain stores in order to increase their revenue from milk sales. This strategy might not be suitable for smallholder farmers, however there is a need for the establishment of a more efficient system of milk collection and transportation to the formal market (major milk processors) as well as the negotiation for milk selling prices that will be suitable for both the producers and processors to make money from milk. Before such an exercise is embarked on, however, it is imperative that a study be

conducted on the economics of smallholder milk production, storage and transportation to facilitate informed decision-making.

2.4 Conclusion

Smallholder dairy producers have a potential to contribute greatly to the Swazi dairy industry. Their poor performance is a result of a myriad of underlying problems, which need to be resolved for this potential to be realised. There remains a great need for farmers to be trained on dairy husbandry and fodder production and conservation. The AI provision service currently in place has to be improved by improving communication between farmers and inseminators to facilitate timely service provision, as well as increasing the number of community-based farmers that are trained in artificial insemination. Government can increase the numbers and genetic quality of heifers and primiparous animals annually sold to smallholder farmers to meet the local stock demand. An elaborate plan, which integrates an efficient milk collection and cooling system with a reasonably priced market, has to be put in place to enable farmers to make some money. The alternative would be to train the farmers on entrepreneurship and marketing strategies, empowering them to process, package and sell their milk as a group.

Chapter III

Performance Deviation From The Standard Lactation Curves: A Case Study Of The Swazi Smallholder Herd

Abstract

This study was aimed at evaluating the performance of the Swazi smallholder dairy herd by comparing it to the performance of a larger, well-managed herd of known pedigree. Lactation records from 252 Jersey cows and 108 Holstein Friesian cows were obtained from Cedara Agricultural Research Institute, covering the periods; July, 2002 to July, 2004 and November, 2002 to April, 2004, respectively. Cows were grouped by parity and calving season and the gamma function proposed by Wood (1969) $Y = An^b e^{-cn}$, was used to fit standard lactation curves on group data. The curve parameters A and b increased with parity, while that of c and s (persistence of lactation at peak) decreased, producing standard lactation curves save for the Holstein Friesian summer calvers, which produced atypical curves. The R^2 values (goodness of fit) increased with parity. Animal parity and calving season were found to influence the peak and shape of the lactation curves and their parameter estimates. The performance of the Swazi smallholder herd showed a mean deviation of the observed daily milk yield of the Holstein Friesian breed from the expected yield to be -3.47 (SD 6.052) kg and that of the Jersey breed was -16.92 (SD 5.473) kg. The mean proportional deviation of observed milk yield from the expected yield for the Holstein Friesian breed was -0.3 (SD 0.37) and that of the Jersey breed was -0.6 (SD 0.19). The proportional milk yield deviation of the Holstein Friesian breed can be explained using the equation, $Y = 0.1322(SE = 0.1293)x - 2.3581$ (SE = 0.20639), where x = expected milk yield and Y is the proportional deviation of the observed milk yield deviation from the expected milk yield. With respect to the smallholder Jersey breed, no relationship was found that could explain the proportional milk yield deviation. The smallholder herd was proved to be underperforming, considering the potential for higher milk yields of the two breeds.

3.1 Introduction

In Swaziland the dairy breeds commonly kept by both large-scale commercial and smallholder farmers are the Holstein Friesian and Jersey. Among the smallholder dairy farmers, the most favoured breed is the Jersey, perhaps for its low maintenance requirements, hardiness, adaptability, lower procurement costs and abundance. A number of these farmers also keep Holstein Friesian dairy cows. The amount of milk produced by smallholder dairy farms in the country is unknown since production records are not kept and the milk is marketed privately. In a number of previous studies (Dlamini, 1990; Ogwang, 1993; FAO, 1994; FAO, 1996; FAO, 1998; Nhlabatsi, 1994; Dlamini and Khumalo, 2000), there was an indication, however, that the production levels of these breeds under this system are below that, which is expected. It is suspected that this is due to the varied systems of management, feeding and breeding practised, most of which are in conflict with recommended dairy husbandry.

In an attempt to evaluate the performance of dairy cows under the Swazi smallholder dairy production system, milk yield records per animal were obtained from the few smallholder farmers who actually kept some milk yield records. To determine the true production potential of the smallholder dairy herd, its performance has to be compared to that of a large herd of known pedigree (preferably the national dairy herd). The performance data of dairy herds in Swaziland is undocumented and hence is not readily available. As an alternative, South African dairy herd performance data were sought, with little success, from the Agricultural Research Council – Animal Improvement Institute (Mostert *et al.*, 2001). The objective of this study was to establish standard lactation curves for both the Jersey and Holstein Friesian breeds. These curves and parameters would then be used as the standard against which to evaluate the performance of the Swazi smallholder herd since both breeds and the semen used in AI are exclusively imported from South Africa.

3.2 Materials and Methods

3.2.1 Source of Data

The values of parameter estimates of the lactation curve models of the South African national dairy herds, compiled by the ARC-Animal Improvement Institute (Mostert *et al.*, 2001) were not available to be used for industrial reasons. Instead, Holstein Friesian breed data were obtained from Cedara Agricultural Institute with the assistance of Mr. T. Dugmore; the production data of the Jersey breed were obtained from a farm neighbouring Cedara Agricultural Institute. The data consisted of records from 252 jersey cows, collected from 18-07-2002 to 20-07-2004, over 20-test days, providing a maximum of two complete successive lactation records per animal. Intervals between test dates did not exceed 75 days. The Holstein Friesian production records had been collected between 15-11-2002 and 22-04-2004 from Cedara Agricultural Institute, covering 13 test days. Holstein Friesian data were collected from 108 cows at an average test day interval of 40 days. The criterion for record inclusion for both breeds was that the lactation should at least be 250 days, therefore, records fewer than this were excluded from the compilation (excluded records are not part of the above-mentioned record numbers). Data were separated into two distinct calving seasons, namely summer (September - March) and winter (April – August). These data were, in addition, classified according to the parity of the cattle.

The Jersey herd was on a high input level of management. The cows were stall-fed on a high level of a total mixed ration (TMR) and then allowed to graze for a limited period of time on a daily basis both in summer and winter. The Holstein Friesian herd, on the other hand, was on a less intense feeding programme. During the summer season the animals were grazed on Kikuyu pastures whereas in the winter they were grazed on Italian Rye grass pastures, supplemented with maize silage and *Eragrostis curvula* hay. In essence, the plane of nutrition was higher during the winter season than during summer. In both seasons, however, the cattle received a supplement of whole soya bean and broken yellow maize,

mixed with mineral premixes in quantities proportional to the quantity of milk produced per animal.

3.2.2 Fitting of The Model

The milk production records were organised according to parity and calving season for both the Jersey and Holstein Friesian breeds. There are a number of mathematical models used to describe the shape of lactation curves (Cobby and Le Du, 1978; Grossman *et al.*, 1986; Batra *et al.*, 1987; Grossman and Koops, 1988; Landete-Castillejos & Gallego, 2000), most of which are commonly used in evaluating the performance of cattle for breeding purposes. In consideration of the objectives of this study and for simplicity, the standard lactation curves were fitted onto the data, using the model proposed and substantiated by Wood (1967, 1969, 1970a, 1970b, 1972, and 1976).

$$Y = An^b e^{-cn} \quad (1)$$

Where Y is milk yield on the n^{th} day of lactation, e is the base of natural logarithms and A , b and c are constants. In this model, A is a representation of the scaling factor of milk production at the beginning of lactation (when $n = 0$), while b and c represent the limiting slope of the curve before and after the peak of lactation, respectively. Equation (1) was converted by natural logarithmic transformation into the linear form:

$$\text{Log}_e Y(n) = \log_e A + b \log_e n - cn \quad (2) \quad (\text{Wood, 1969})$$

When equating the first derivative of equation (2) to zero (with respect to n) and solving for n , the solution is; $n = b/c$. By substituting n with this value in equation (1), the peak milk yield can be estimated to be:

$$Y_{\text{peak}} = A (b/c)^b e^{-b} \quad (3) \quad (\text{Wood, 1967 and 1969})$$

Persistency of lactation (number of days during which lactation is at its peak) can be estimated using the following equation: (Wood, 1969).

$$S = - (b+1) \ln c \quad (4)$$

Data were log transformed and multiple linear regression performed using SAS (2002) to establish the parameter estimates for the constants, A , b and c . A similar procedure for deriving lactation curve parameters has been described by Wood (1967, 1969, 1970a, 1970b, 1972, and 1976) and Collins-Lusweti (1991). Using this procedure, lactation curves were fitted separately for the Jersey and Holstein Friesian herds, according to calving season and parity. In the Holstein herd, data on the first and second parity had to be combined due to a low number of available lactation records for the second parity. Lactation records for the parities ≥ 5 were also combined due to the low number of available records.

3.2.3 The Swazi Smallholder Herd

Since the Swazi smallholder farmers did not have detailed records pertaining to the parity and lactation stages of their lactating cows, the level of performance evaluation was limited. From the established lactation curve parameters for both the Jersey and Holstein Friesian breeds, only the calving season parameters could be used to establish the expected milk production levels. With respect to the Jersey breed, the mean values of both winter and summer calving lactation curve parameters were used to establish the lactation curve (expected milk yields). For Holstein Friesians, only the winter calving parameters were used because those for summer calving produced atypical lactation curves. The parameters were used to project the lactation curves showing the expected milk yields for the two breeds (without respect to parity or calving season). The lactation data of the Swazi smallholder dairy herd were obtained from only a handful of farmers who kept detailed records and consisted of 14 records for Holstein Friesians and 68 for Jersey cows. The observed milk yields for each breed were compared to the expected yields in order to determine the disparity, if any between the two herds, since the Cedara herd was being used as the standard against which the performance of the Swazi herd was being evaluated.

For each record of the Swazi smallholder herd, the expected (potential) milk yield was subtracted from the observed milk yield in order to quantify the amount of yield deviation. The actual difference between the expected and observed yield was then expressed as a fraction of the expected yield for each record in order to get the proportional yield deviation. The mean deviations and the standard deviations for each breed were calculated. Linear regression analysis was used in an attempt to explain the proportional yield deviations, wherein the proportional deviations were regressed on the expected milk yield. A multiple regression analysis (SAS, 2002) was further performed by regressing the observed milk yield on the expected (potential) milk yield and the following dummy variables: milking frequency, breeding methods, dairy concentrate feeding, winter-feed supplementation and hay feeding in winter. The effect of these variables was not significant ($P > 0.05$).

If poor nutritional management is the driving force behind low milk yields, then the deviations of the observed from the expected milk yield would be low during periods of lactation typically characterised by low milk yields and high during high-milk yielding periods (early to mid lactation). This is based on the assumption that an animal would be better able to closely approach its requirements if subjected to a low plane of nutrition when it is at a low productive state.

3.3 Results & Discussion

3.3.1 The Cedara Herds

In genetics, the phenotype is said to be a result of genotype and environmental interaction ($P = G+E$). It follows therefore that a cow's milk yield level is a result of its genotype and environmental factors. The environmental factors influencing milk production can be categorised into fixed environmental and management factors. These factors include animal age, age at first calving, parity, calving season, stage of lactation, milking frequency, nutrition, interval from calving to re-conception and animal health (Collins-Lusweti, 1991;

Mostert *et al.*, 2001; Brotherstone *et al.*, 2004; Rekik and Ben Gara, 2004). These environmental factors have a multivariate effect on milk yield, affecting not only the total milk yield but also the rate of milk production throughout the length of lactation i.e. the shape of the lactation curve (Rekik and Ben Gara, 2004). There is an expected degree of variation in the performance of individual cattle within a herd in that some give milk yields that are above the herd mean while others yield below the mean even though they are under similar management. These differences can be attributed to genetic variation between the cattle.

The parameters A and b and the R^2 (goodness of fit) values increased inconsistently, as parity increased in the Cedara herd, but the c and s values decreased (Table 3.1 and 3.2) similar to the observations of Collins-Lusweti (1991). In a typical evaluation system based on daily yields, lactation curves will vary depending on lactation number, month or season of calving and age at calving (Brotherstone *et al.*, 2004). In Zimbabwe, Collins-Lusweti (1991) found that herd, parity and calving season had significant effects on the lactation curve parameters (A , b , c and s) of both Holstein Friesian and Jersey breeds. The estimated peak milk yields (Y_{peak}), for both breeds are notably higher for winter calving animals than for summer calvers (Table 3.1 and 3.2). This is true when considering both the interaction of parity and calving season and also when calving season is the only factor under consideration. The Jersey and Holstein Friesian herds both showed an increasing peak milk yield with parity, up to the fourth parity, after which the estimated peak milk yield started to decline (Fig. 3.1).

Milk yield is determined by secretory epithelial cell numbers and by the secretory activity per cell (Forsyth, 1986). Heifers first calve at about two years of age, when they are still growing, having not attained their mature weight. The successive parities result in an increase in milk yield since pregnancy has mammogenic and lactogenic effects (Capuco *et al.*, 1997; Capuco and Akers, 1999).

Table 3.1: Lactation curve parameter estimates for the Jersey herd.

| Parity | Season | Log _e A | A | b | c | ln (c) | S | Y _{peak} | R ² |
|----------------------------------|--------|--------------------|------|-------|---------|--------|-----|-------------------|----------------|
| 1 | Winter | 2.71 | 15.0 | 0.191 | -0.0022 | -6.11 | 7.3 | 29.1 | 0.26 |
| | Summer | 2.89 | 18.0 | 0.144 | -0.0021 | -6.19 | 7.1 | 28.6 | 0.19 |
| 2 | Winter | 2.93 | 18.8 | 0.193 | -0.0029 | -5.83 | 7.0 | 34.7 | 0.37 |
| | Summer | 2.87 | 17.6 | 0.240 | -0.0046 | -5.39 | 6.7 | 35.9 | 0.54 |
| 3 | Winter | 2.83 | 17.0 | 0.257 | -0.0039 | -5.54 | 7.0 | 38.7 | 0.55 |
| | Summer | 2.90 | 18.1 | 0.252 | -0.0049 | -5.32 | 6.7 | 37.9 | 0.57 |
| 4 | Winter | 2.79 | 16.3 | 0.257 | -0.0040 | -5.52 | 6.9 | 36.7 | 0.49 |
| | Summer | 2.83 | 16.9 | 0.280 | -0.0052 | -5.25 | 6.7 | 39.0 | 0.58 |
| 5 | Winter | 3.17 | 23.7 | 0.158 | -0.0029 | -5.86 | 6.8 | 38.1 | 0.65 |
| | Summer | 3.27 | 26.3 | 0.117 | -0.0026 | -5.94 | 6.6 | 36.5 | 0.37 |
| 6 | Winter | 2.47 | 11.8 | 0.350 | -0.0059 | -5.13 | 6.9 | 34.8 | 0.73 |
| | Summer | 2.68 | 14.6 | 0.316 | -0.0055 | -5.20 | 6.8 | 38.2 | 0.79 |
| Calving Season Parameters | | | | | | | | | |
| | Winter | 2.98 | 19.6 | 0.167 | -0.0027 | -5.91 | 6.9 | 33.1 | 0.35 |
| | Summer | 2.96 | 19.3 | 0.192 | -0.0036 | -5.62 | 6.7 | 34.2 | 0.41 |

Table 3.2: Lactation curve parameter estimates for the Holstein Friesian herd.

| Parity | Season | Log _e A | A | b | c | ln (c) | S | Y _{peak} | R ² |
|----------------------------------|--------|--------------------|-------|--------|---------|--------|-----|-------------------|----------------|
| 1 & 2 | Winter | 2.08 | 8.0 | 0.306 | -0.0048 | -5.33 | 7.0 | 21.0 | 0.52 |
| | Summer | 3.45 | 31.6 | -0.203 | 0.0016 | -6.43 | 5.1 | 14.5 | 0.09 |
| 3 | Winter | 1.95 | 7.1 | 0.335 | -0.0042 | -5.48 | 7.3 | 22.0 | 0.35 |
| | Summer | 5.15 | 172.5 | -0.558 | 0.0027 | -5.90 | 2.6 | 15.5 | 0.28 |
| 4 | Winter | 1.78 | 6.0 | 0.430 | -0.0055 | -5.20 | 7.4 | 25.2 | 0.79 |
| | Summer | 4.62 | 101.9 | -0.547 | 0.0060 | -5.12 | 2.3 | 14.9 | 1.00 |
| ≥ 5 | Winter | 2.25 | 9.5 | 0.270 | -0.0040 | -5.51 | 7.0 | 22.4 | 0.35 |
| | Summer | 3.39 | 29.6 | -0.056 | -0.0011 | -6.85 | 6.5 | 25.1 | 0.38 |
| Calving Season Parameters | | | | | | | | | |
| | Winter | 2.08 | 8.0 | 0.312 | -0.0044 | -5.43 | 7.1 | 22.1 | 0.39 |
| | Summer | 3.45 | 31.5 | -0.162 | 0.0008 | -7.17 | 6.0 | 15.6 | 0.07 |

The lactation curves of Holstein Friesian summer calvers (Fig. 3.2b) were overtly atypical (Rekik and Ben Gara, 2004) forming a curvilinear curve in which the milk yield initially declined to a point where it became constant. In the incomplete gamma function (Wood, 1967) used to fit the curves; *A* is the parameter estimate of milk yield at the beginning of lactation, *b* is the parameter that explains the ascending phase of the curve before it reaches its peak, *c* is the parameter that explains the declining phase of the curve after peak milk yield. Rekik and Ben Gara (2004) defined a lactation curve as atypical if either *b* or *c* (parameter estimates) were negative. In this study, the parameter *b* for all the overtly atypical lactation curves (Holstein Friesian summer calvers) was negative ($b < 0$). The parameter *c* for the remainder of the Cedara herds was found to be positive ($c > 0$) for

Holstein Friesian winter calvers (Fig. 3.2a) and for the whole Jersey herd (winter and summer calvers) when used in the gamma function (equation 2). The resultant lactation curves appeared to be normal except for the differences in the steepness of the slopes during the inclining and declining phases of the curves for different parities and calving seasons.

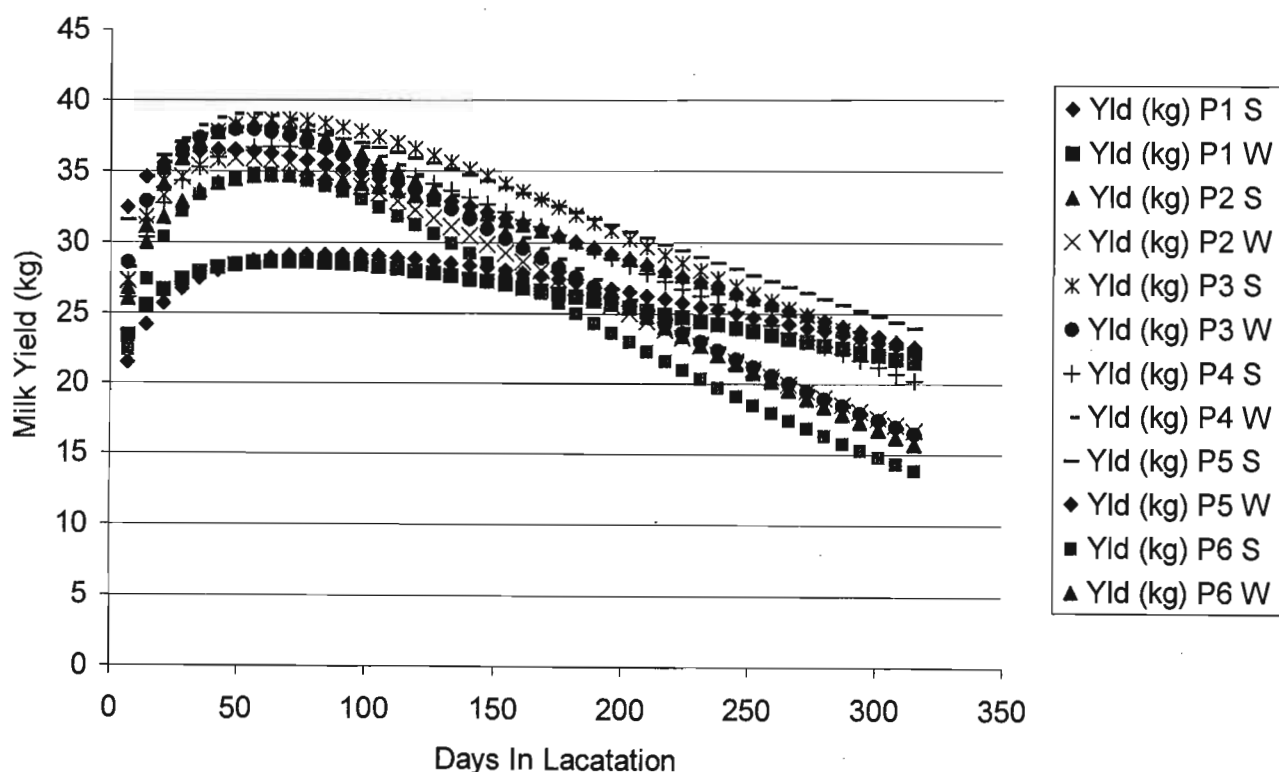


Figure 3.1: Lactation curves of the Cedara Jersey herd (summer and winter calvers).

(Yld (kg) – Milk Yield, Kg; **P1S** – 1st Parity, Summer Calvers; **P1W** – 1st Parity, Winter Calvers; **P2S** – 2nd Parity, Summer Calvers; **P2W** – 2nd Parity, Winter Calvers; **P3S** – 3rd Parity, Summer Calvers; **P3W** – 3rd Parity, Winter Calvers; **P4S** – 4th Parity, Summer Calvers; **P4W** – 4th Parity, Winter Calvers; **P5S** – 5th Parity, Summer Calvers; **P5W** – 5th Parity, Winter Calvers; **P6S** – 6th Parity, Summer Calvers; **P6W** – 6th Parity, Winter Calvers)

In South Africa, Mostert *et al.* (2004) observed that cows calving in June/July had typical lactation curves, which differed from that of cows calving in December/January and that the highest daily milk yields were obtained from cows calving in the cooler months (April to September). Tekerli *et al.* (2000) observed that the length of the open period in cattle influenced the shape of the lactation curves, in that cattle with short postpartum intervals to

re-conception had lower persistencies than cattle with longer postpartum intervals and the rate of decrease in milk yield after peak lactation decreased with an increase in the open period. In concurrence, Brotherstone *et al.* (2004) observed a 1.50kg increase in average test day milk yield of multiparous (second or third lactation), Holstein Friesian cows that had an open period of 150 days in the previous lactation compared to those that were open for only 50 days.

The atypical lactation curves observed in the Holstein Friesian herd (summer calvers) could be a factor of management practices employed in the farm. The feeding management practised on the farm is such that the plane of nutrition is lower in the summer season (Kikuyu pasture only) than it is in the winter, resulting in an early monotonous decline in the milk yield of the summer calvers. Subsequently in the winter season, when the plane of nutrition is increased, the response is either an increase or constant milk yield during what is supposed to be the declining phase of the lactation.

3.3.2 Comparative Analysis Of The Swazi Smallholder Herd

The lactation curves were viewed as the potential or expected milk yield for the smallholder herd. The comparison confirms the suspicion that the smallholder herd was generally performing below the breed potential. Whilst three Holstein Friesian cows performed at or above the expected level (Figure 3.3a), none of the Jerseys reached their potential. It should, however be noted that the Holstein Friesian breed normally has a higher potential milk yield than suggested by the curve. Although some of the Jersey cows performed close to the expected levels, the majority of the herd performed far below expectation (Figure 3.3b). The main reason for the underperformance is largely suspected to be the result of substandard management, mainly poor nutrition and breeding practices.

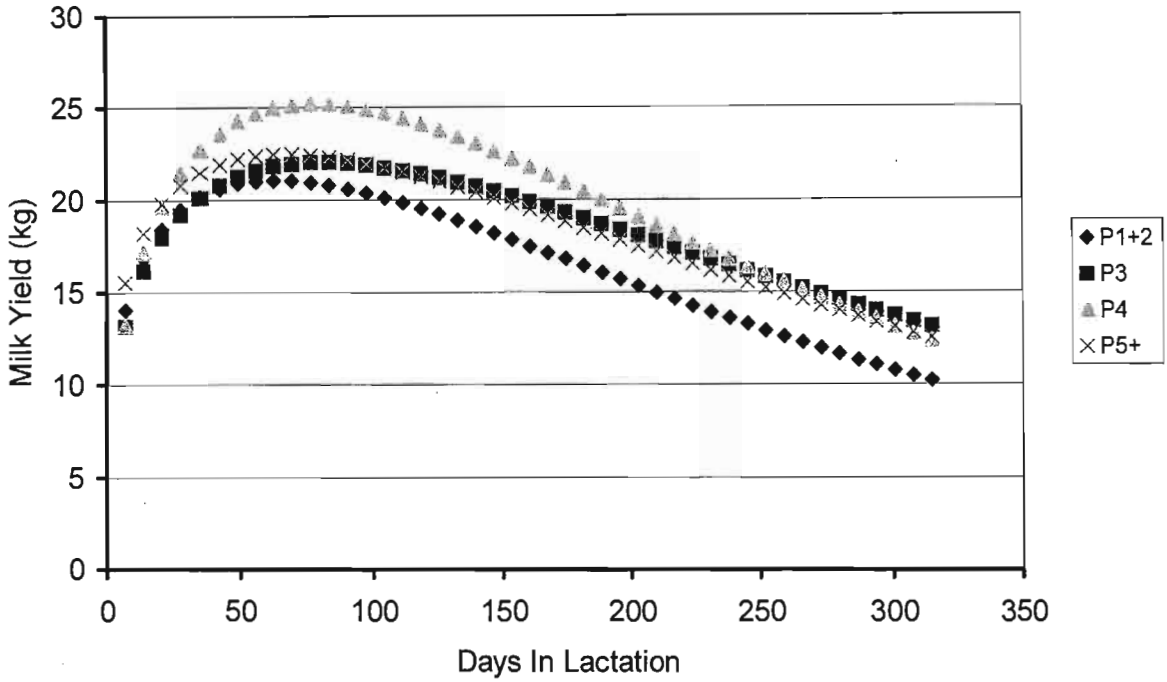


Figure 3.2a: Lactation curves of Holstein Friesian herd (winter calvers) of different parity.

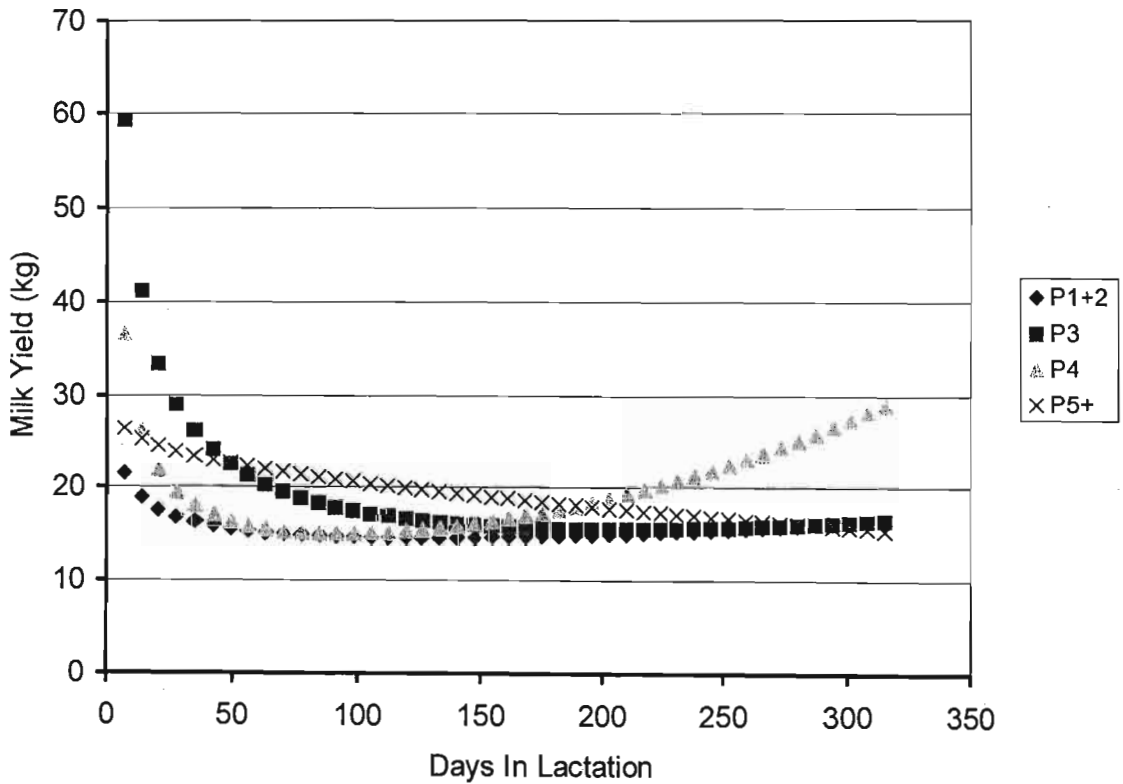


Figure 3.2b: Lactation curves of Holstein Friesian herd (summer calvers) of different parity.

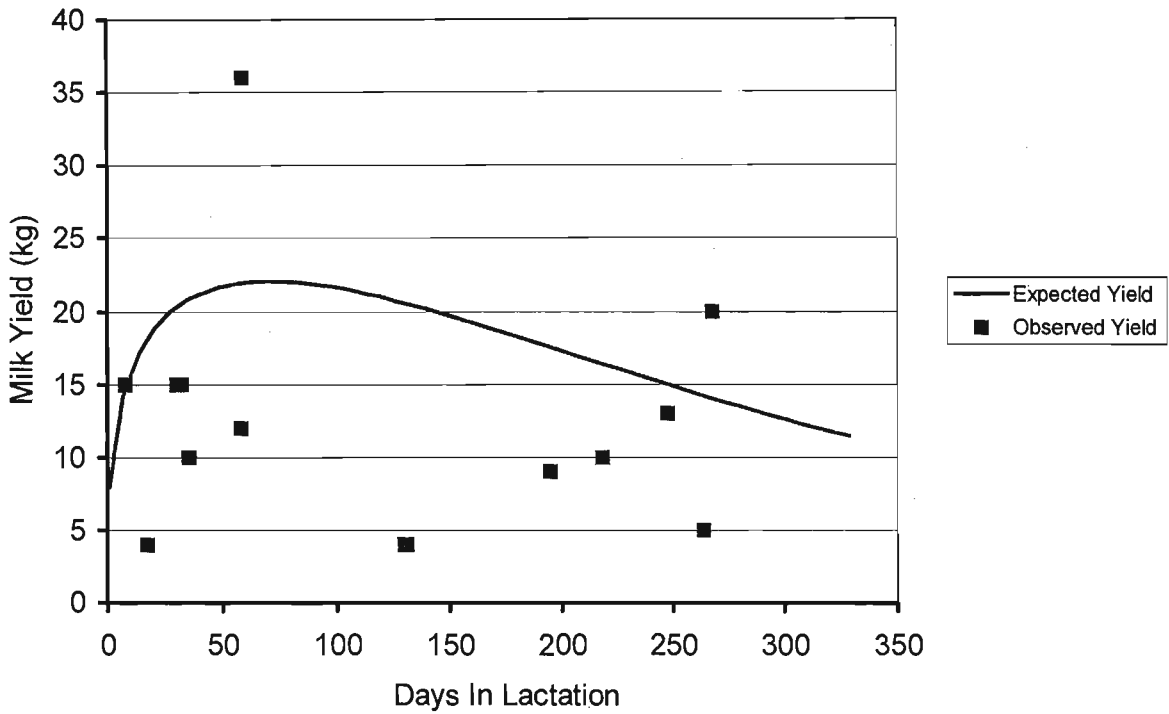


Figure 3.3a: Comparison of expected and observed milk yield of Holstein Friesian cows.

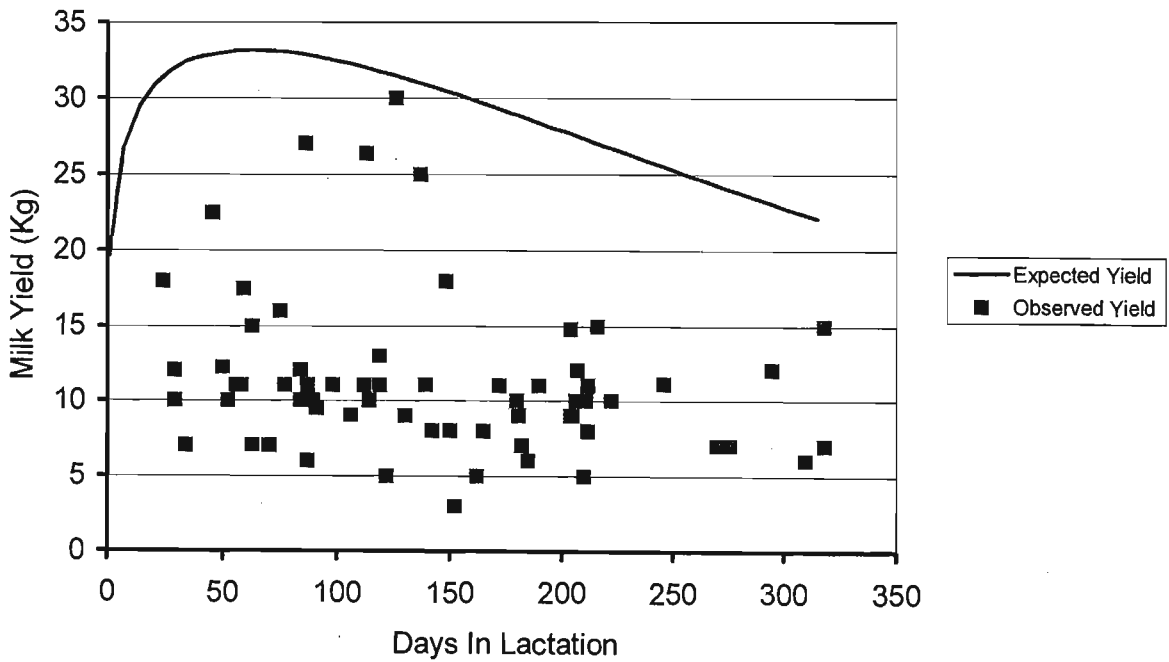


Figure 3.3b: Comparison of expected versus observed milk yield of Jersey cows.

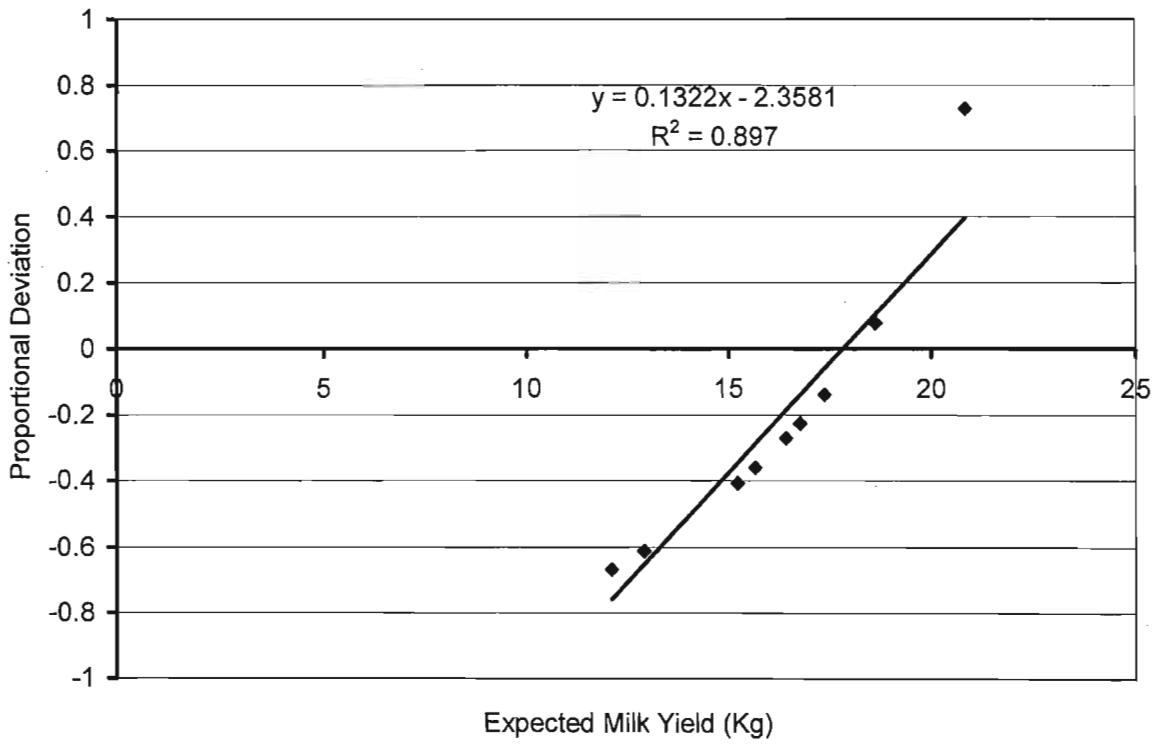


Figure 3.4a: Proportional milk yield deviation of the observed yield from the expected of Holstein Friesian.

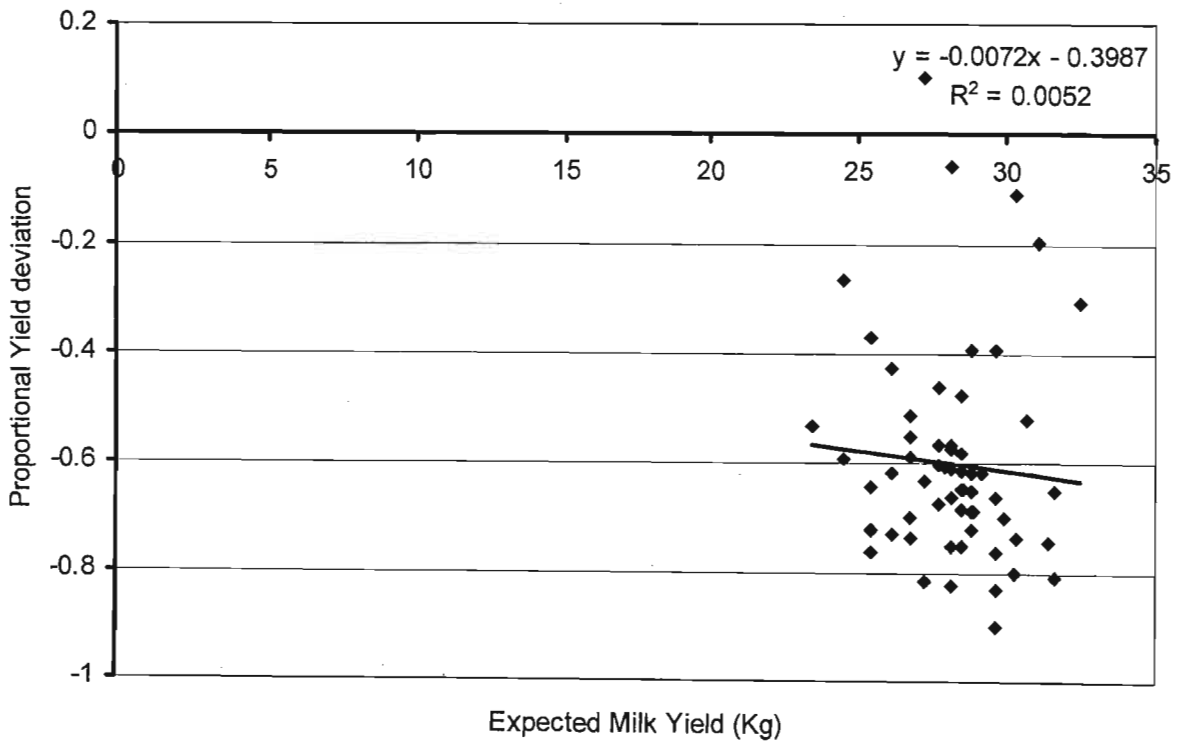


Figure 3.4b: Proportional milk yield deviation of the observed yield from the expected of Jerseys.

Given that the comparative analysis had suggested that there was a disparity between the expected milk yield and the observed yields from the smallholder herd, an attempt was made to understand and quantify the observed yields as a function of the expected yields. The mean deviation of the observed daily milk yield of the Holstein Friesian breed from the expected yield was -3.5 ± 6.05 kg and that of the Jersey breed was -16.9 ± 5.73 kg. The mean proportional deviation of the observed milk yield from the expected yield for the Holstein Friesian breed was -0.3 ± 0.37 and that of the Jersey breed was -0.6 ± 0.19 . The linear regression of proportional yield deviations (Y) on expected yield (x) gave a strong linear relationship for the Holstein Friesian breed (Figure 3.4a), having an R^2 value of 0.897 and gave the equation, $Y = 0.1322(\text{SE} = 0.1293) x - 2.3581 (\text{SE} = 0.20639)$. This could perhaps be the result of the low number of records of observed milk yields from the smallholder herd. The high R^2 value suggests that the equation could be used to project the milk yield of the Swazi smallholder Holstein herd from the expected yield. The Jersey herd (Figure 3.4b) on the other hand had more variation in the proportional yield deviation from the expected (potential) yield, a fact illustrated by the low R^2 value (0.0056). The parameter estimates of both the Y intercept and expected milk yield (slope) were non-significant ($P > 0.05$) in the Jersey herd.

An attempt to establish a predictive model for the proportional deviations of the observed milk yields from the expected yields for both breeds in Swaziland using multiple linear regression proved futile. The R^2 value for the Holstein Friesians was high (0.92) and that of the Jersey breed was poor (0.038). On both occasions the management variables used could not achieve a probability of entry into the model of up to 15%, hence the model could not be used to explain the observed proportional milk yield deviations.

This great variation could perhaps be explained by the high number of records of observed yield on smallholder farms since many farms kept Jersey cattle and these had widely variable levels of management, consequently the performance of the animals varied greatly.

A clear example of this is shown in Figure 3.3b, where some cows in early lactation had milk yields ranging from 5 to 15 kg/day while some in late lactation had the same yield range. Considering that the cattle are of the same breed, a logical explanation is that most of the animals that had low milk yields in early lactation were under low levels of management and that those with high yields in late lactation were under good management. Mostert *et al.* (2004) found that the herd, season and age class had an effect on 305-day milk, butterfat and protein yield, explaining on average 64% and 53% of the variation in the South African Holstein Friesian and Jersey breeds, respectively.

It should, however, be noted that the cows in Figures 3.3a and b, were of different age classes, parity, age at first calving, calving seasons, calving intervals and herds. It has been established that fixed environmental and management factors have a bearing on the milk yield of cattle (Collins-Lusweti, 1991; Mostert *et al.*, 2001; Brotherstone *et al.*, 2004; Rekik and Ben Gara, 2004). Since the only available information about the smallholder herds was the lactation stage (days in lactation) and the test-day milk yield, the other factors mentioned above could not be catered for. Although some management factors were known, most were qualitative and were further found to be poorly associated with the observed milk yields.

3.4 Conclusion

The lactation curves fitted using the data obtained from Cedara and the neighbouring farm, clearly illustrate the effect of calving season, animal age and herd on the shape of the lactation curves. These curves can and were acceptably used for the performance evaluation of the Swazi smallholder dairy herd. The smallholder herd was proved to be underperforming, considering the potential for higher milk yields of the two breeds. There is a need to improve the breeding, nutrition and other management aspects of the smallholder herd. With regard to establishing a prediction model for the Swazi smallholder herd, a

detailed performance evaluation study would have to be conducted on the national herd. The main obstacle to achieving this, however, would be the fact that the farmers generally do not keep records; hence accounting for the variation in production levels would remain almost impossible.

Chapter IV

Typology And Constraint Identification Of The Swazi-Smallholder Dairy Producers

Abstract

The study was conducted in an effort to understand smallholder dairying in Swaziland and the constraints faced by farmers in dairying. A sample of 118 smallholder dairy farmers from Manzini and the surrounding areas was analysed using multivariate statistics to categorise them based on their herd sizes, herd structures, management and success perceptions in dairying. The analysis produced three clusters (categories): cluster 1 had the largest herd sizes and poor milk production efficiency; cluster 2 had intermediate herd sizes, the highest number of farmers and more efficient milk production per cow. This cluster, however, had the highest proportion of calf mortalities. Cluster 3 had the smallest herd size, the lowest calf to cow ratio and the second highest calf mortality. Record keeping across all clusters was very poor and the average milk yield per cow was generally low. Most of the farmers do not appreciate the importance of annual calving of their cows as an integral part of the success of their dairy projects and winter feed supplementation is very poor across all the clusters. There remains a great need for the enlightenment of the farmers on the importance of good nutrition, breeding, calf rearing and record keeping in successful dairying.

4.1 Introduction

Swaziland has a growing number of smallholder dairy farmers, however as much as there are newcomers into the industry, there appears to be a growing trend of what were considered to be established farmers, leaving the industry (Dlamini and Khumalo, 2000 and extension observation). A number of studies have been conducted in the past (Dlamini, 1990; Ogwang, 1993; FAO, 1994; FAO, 1996; FAO, 1998; Dlamini and Khumalo, 2000), with the aims of understanding the constraints encountered by the smallholder dairy producers.

Dlamini (1990) and Ogwang (1993) noted the poor development of planted pastures by smallholder farmers, owing to the scarcity of land, water, seed, skills, capital, machinery and poor provision of agricultural extension service. FAO (1996) reported that the demand for milk had continually exceeded the supply and that imported milk accounted for more than 60% of milk sold in the formal market in the country. Smallholder farmers prefer to sell their milk privately since the prices offered in the formal market for raw milk are very low (Nhlabatsi, 1994; FAO, 1996 and 1998; Dlamini and Khumalo, 2000). The efficiency of milk production per cow is generally very low amongst smallholder farmers and is further influenced by the high cost of commercial dairy concentrate and poor breeding practices (Dlamini, 1990; Nhlabatsi, 1994; Dlamini and Khumalo, 2000).

Dairying, amongst other agricultural enterprises, is a source of food and income for most people in rural Swaziland. This study is part of a comprehensive scrutiny into smallholder dairying and was aimed at better understanding the types (categories) of smallholder dairy farmers based on their herd sizes, management systems and success perceptions in the enterprise. In addition the constraints that hamper the productivity of their enterprises would be identified in relation to the categories and ultimately suggestions on how the problems can be overcome, from a comprehensive view of the smallholder dairy industry in the country. In the previous chapter, the performance of the smallholder herd could not be explained in terms of regression model based on proportional milk yield deviations, hence further investigation into cluster analysis to explain it.

4.2 Materials and Methods

In a study aimed at understanding the production system and constraints on smallholder dairying in Swaziland, a survey was conducted between November 2003 and March 2004. A total number of 118 smallholder dairy farms were covered, mainly on SNL in the Manzini region and some surrounding areas. The collected data included visit (test) day milk yields,

milking frequency, breeding & reproductive performance records, herd structure, feeding strategies, milk marketing and constraints on smallholder dairying. In addition, the farmers' perception of success in smallholder dairying was assessed based on a categorical response to five measures of farm and herd productivity. These measures were, increased milk yield, cows calving annually, high milk sales, herd size increase and making money. The farmers were asked whether or not they agreed with these measures as success indicators and their individual responses to each measure were categorised on a nominal numerical scale of 1 to 5, with 1= strongly disagree, 2= disagree, 3= Neutral, 4= Agree and 5= Strongly Agree.

The data were analysed using multivariate statistics. The initial step was the application of a variable reduction technique (ACELUS) on six variables (number of lactating cows, dry cows, calves, heifers, bullocks and bulls) in order to generate canonical variables to be used in a hierarchical cluster analysis (Ward's method) to determine the appropriate number of clusters. Two canonical variables were generated and these accounted for 99.98% of the variation. The pseudo-F, the pseudo- t^2 and the cubic clustering criterion (CCC) were all unanimous for a 3-cluster solution, which accounted for 91.7% of the variation. These clusters were further finely adjusted using a non-hierarchical procedure FUSCLUS (SAS, 2002). The validity of these clusters was established using canonical discriminant analysis on variables not used in clustering (i.e. milking frequency, record keeping, calf mortalities, calf to cow ratio, breeding management, winter hay feeding, increased milk yield, cows calving annually, high milk sales, herd size increase and making money). Milking frequency was either once or twice a day. Record keeping response was either yes or no (yes= 1; no= 0). Calf mortality was expressed as the actual number of observed calf deaths in each farm, irrespective of herd size. Calf to cow ratio = number of live calves as a proportion of the sum of both lactating and dry cows per farm. Breeding management was given nominal values: bulls only = 1, AI only = 2, the combined use of bulls and AI = 3. With respect to the practice of winter hay feeding, the farmers were placed into two categories: winter hay feeding = 1 and no winter hay feeding =0.

Principal Components Analysis (ter Braak and Smilauer, 2003) was conducted on the same data in order to further explore the existing relationships between the variables measured. The farmers were categorised as samples, the herd dynamics and management were considered as species and the farmers' perception of success variables were considered to be supplementary data. A standardised and centred Principal Components Analysis (PCA) was performed and ordination plots generated to extract the relationships between the variables. The variables under herd dynamics were: number of lactating cows, heifers, dry cows, calves, bullocks, bulls, proportion of calves to cows, total milk yield per farm, average milk yield per cow and proportional calf mortality (calf mortalities expressed as a proportion of the sum of both the live and dead calves). The management variables included record keeping, winter hay feeding, breeding methods (management), winter feed supplementation and dairy concentrate feeding. The success perception variables used remained the same as described above.

Amongst the management variables, winter-feed supplementation and dairy concentrate feeding were given nominal variables to represent the different systems of management practised by the farmers. Winter supplement feeding was categorised as follows: none = 0, dry fodder = 1, silage and/or pasture = 2, hominy chop, broken or crushed yellow maize and molasses meal = 3, dry fodder, maize silage and/or fattening ration = 4. The daily commercial dairy concentrate feeding was assigned four categories: None = 0, Yes = 1, Yes but mixed with other ingredients at home = 2, Occasional commercial dairy concentrate feeding = 3 and home made rations = 4.

4.3 Results and Discussion

Cluster 1 contains 3.4% of respondents; it has the highest numbers of lactating cows, calves, dry cows, heifers and bullocks. The farmers in this cluster were also exclusively those that owned bulls. Cluster 2 contains 77.1% of respondents; it has an intermediate number of

lactating cows, calves, a single dry cow and heifer and no bulls or bullocks. Cluster 3 contains 19.5% of respondents, has the lowest number of lactating cows and calves, a single heifer and bullock and no dry cow or bull. Consequently, clusters 1, 2 and 3 can be described as large, intermediate and small herds. Details of these clusters of farmers are given in Table 4.1.

Table 4.1: Cluster means of classification variables and group means of the first two discriminant functions for a 3-cluster solution of smallholder dairy farmers.

| Variables | Cluster Numbers | | | F- ratio | Probability |
|----------------|-----------------|----------|----------|----------|-------------|
| | 1 (n=4) | 2 (n=91) | 3 (n=23) | | |
| Lactating Cows | 9.5 | 2.6 | 1.5 | 23.86 | 0.0001 |
| Dry Cows | 3.8 | 0.6 | 0.5 | 16.15 | 0.0001 |
| Calves | 9.3 | 2.0 | 1.1 | 27.46 | 0.0001 |
| Heifers | 3.5 | 1.1 | 0.7 | 5.97 | 0.0001 |
| Bullocks | 4.3 | 0.0 | 1.0 | 619.64 | 0.0001 |
| Bulls | 0.8 | 0.3 | 0.1 | 3.36 | 0.0381 |

Since the herd structure variables were used for farmer classification, the following hypotheses were tested to validate the typology developed in Table 4.1:

1. Farmers in cluster 1 (with large herds) should have the highest milk yields. They are also expected to perceive success in dairying as having increasing herd size, high milk yields, high milk sales and making money. However, the drive to increase milk yield by increasing herd size may compromise milk production efficiency.
2. The farmers in cluster 2 are expected to have intermediate milk yields and their management should be focused on increased efficiency of milk production per cow.
3. The farmers in cluster 3 are expected to have the lowest milk per farm and may comprise of beginners who are still enthusiastic about dairying and deriving more milk per cow.

Discriminant function testing of these hypotheses is given in Table 4.2.

Table 4.2: Total-sample standardised canonical coefficients of discriminant variables.

| Variable | Canonical Function 1 | Canonical Function 2 |
|--|----------------------|----------------------|
| Milking frequency | 0.0248 | -0.391 |
| Record keeping | -0.060 | 0.074 |
| Proportional calf mortality | -0.051 | -0.846 |
| Calf to cow ratio | 0.041 | -0.581 |
| Breeding management | -0.563 | 0.305 |
| Winter hay feeding | -0.043 | -0.223 |
| Average milk yield per cow | -0.419 | -0.542 |
| Total milk yield/ day / farm | 0.755 | 0.427 |
| Winter feed supplements | -0.305 | 0.496 |
| Annual calving * | -0.095 | 0.376 |
| Increased milk yield * | 0.407 | -0.001 |
| High milk sales * | 0.430 | -0.028 |
| Herd size increase * | -0.044 | 0.294 |
| Making money * | -0.111 | -0.080 |
| Group Means (centroids) following discriminant analysis | | |
| Cluster 1 | 2.02 | 1.60 |
| Cluster 2 | 0.10 | -0.23 |
| Cluster 3 | -0.96 | 0.68 |

*Denotes variables used as measures of farmer perception of success.

Variables that have loadings of absolute values greater than 0.3 are considered to be significant discriminants (Hair *et al.*, 1992). The first two discriminant functions accounted for 59.7% of the variation, suggesting that a reasonable classification had been achieved. Function 1 (Table 4.2) loaded significantly for the total milk yield per day per farm (0.75), average milk yield per cow (-0.42), breeding management (-0.56) and winter supplementation (-0.31), and for the success perceptions: increasing milk yield (0.41) and high milk sales (0.43). The group means for function 1 sufficiently validate and distinguish the farmers with large herds (cluster 1) from the intermediate (cluster 2) and small (cluster 3) herds. The group means further differentiate cluster 2 from cluster 3. Function 2 loaded highly for milking frequency (-0.39), proportional calf mortality (-0.85), calf to cow ratio (-0.58), breeding management (0.31), average milk yield per cow (-0.54), milk yield per day per farm (0.43), winter supplementation (0.50), and for the success perceptions: annual

calving of cows (0.38) and increasing herd size (0.29). The group means for this function distinguish cluster 1 from the other two clusters, and further separate cluster 3 from cluster 2 (Table 4.2).

Table 4.3: GLM procedure means and standard deviations of each discriminant variable in all three clusters.

| Discriminant Variables | Cluster 1 (N=4) | Cluster 2 (N=91) | Cluster 3 (N= 23) |
|-------------------------------|------------------------|-------------------------|--------------------------|
| Milking frequency | 1.5 ± 0.58 | 1.8 ± 0.42 | 1.8 ± 0.42 |
| Record keeping | 0.25 ± 0.50 | 0.22 ± 0.42 | 0.22 ± 0.42 |
| Calf to cow ratio | 69.5% ± 29% | 63% ±40% | 52.5% ± 42% |
| Proportional calf Mortality | 10.8% ±18% | 20.5% ± 31.6% | 14.7% ± 29.4% |
| Breeding management | 1.25 ± 0.50 | 1.40 ± 0.63 | 1.61 ± 0.89 |
| Hay winter feeding | 0.75 ± 0.50 | 0.73 ± 0.45 | 0.83 ± 0.39 |
| Average milk yield/cow | 4.93 ± 4.62 | 7.23 ± 4.90 | 7.07 ± 4.74 |
| Total milk yield/day/farm | 56.5 ± 69.4 | 19.9 ± 22.8 | 12.5 ± 11.2 |
| Winter feed supplements | 1.75 ± 0.96 | 1.45 ± 0.98 | 2.08 ± 1.28 |
| Annual calving * | 3.0 ± 2.0 | 2.6 ± 1.65 | 3.35 ± 1.30 |
| Increased milk yields * | 4.5 ± 0.58 | 3.99 ± 0.55 | 3.74 ± 0.54 |
| High milk sales * | 4.5 ± 0.58 | 3.99 ± 0.64 | 3.83 ± 0.39 |
| Herd size increase * | 4.5 ± 0.58 | 3.74 ± 1.05 | 3.87 ± 0.92 |
| Making money * | 4.25 ± 0.50 | 3.96 ± 0.58 | 4.0 ± 0.30 |

* Denotes variables used as a measure of farmer success perception

Table 4.3 reveals the subtle differences of the management variables and success perceptions between farmers in the three clusters. The calf to cow ratio is higher for farmers in cluster 1 than for those in clusters 2 and 3, respectively (Table 4.3), owing in part to the low relative calf mortality observed in this cluster and perhaps efficient breeding management. Relative calf mortality and average milk yield per cow were highest in cluster 2, intermediate in cluster 3 and the lowest in cluster 1. Total milk yield per farm was highest in cluster 1, intermediate in cluster 2 and the lowest in cluster 3, perhaps due to the number of lactating cows in these clusters as shown in Table 4.1. The means and standard deviations of farmers' perception of success showed a range of perceptions within each cluster, however, the means indicated that a majority of the farmers were indifferent about the importance of annual calving of cows as an influential factor to the success of their dairy projects. This suggests that there is a need for farmer education on the importance good management, record keeping and annual calving of cows in dairy production.

4.3.1 Principal Components Analysis (PCA)

The PCA correlation matrix revealed that among the variables used to measure farmer perception of success, annual calving of cows was very poorly correlated to milk yields, milk sales, herd size increase and making money (0.27, 0.24, 0.40 and 0.23, respectively). This indicates that the majority of the respondents do not associate annual calving of cows to the above-mentioned measures of success. This is perhaps one reason for the poor reproductive performance and consequently poor milk yields among the smallholder farmers. Interestingly, the respondents' success perception shows high positive correlations of milk sales, herd size increase and making money to milk yield (0.55, 0.53 and 0.60, respectively). High milk sales, was further found to be strongly correlated to making money (0.79) and increases in herd size (0.54). The correlation between herd size increase and making money was 0.57. These relationships are graphically illustrated in Figure 3.5 (PCA scatter plot). Expectedly, farmers are aware that they need higher milk yields and efficient milk marketing in order to make money in dairying. Their means of increasing milk yield, however, appears to be exclusively by increasing the number of lactating cows rather than improving milk production efficiency per cow. In what appears to be a conundrum, increasing the herd size is highly correlated to making money, whereas on the other hand the annual calving of cows is poorly correlated to making money and the other measures of success. The question that arises then is how the farmers manage to increase their herd sizes, considering the poor reproductive performance of their stock. The only plausible answer would perhaps be that they mainly rely on the acquisition of stock from other sources in order to increase their own herds in the drive to make money.

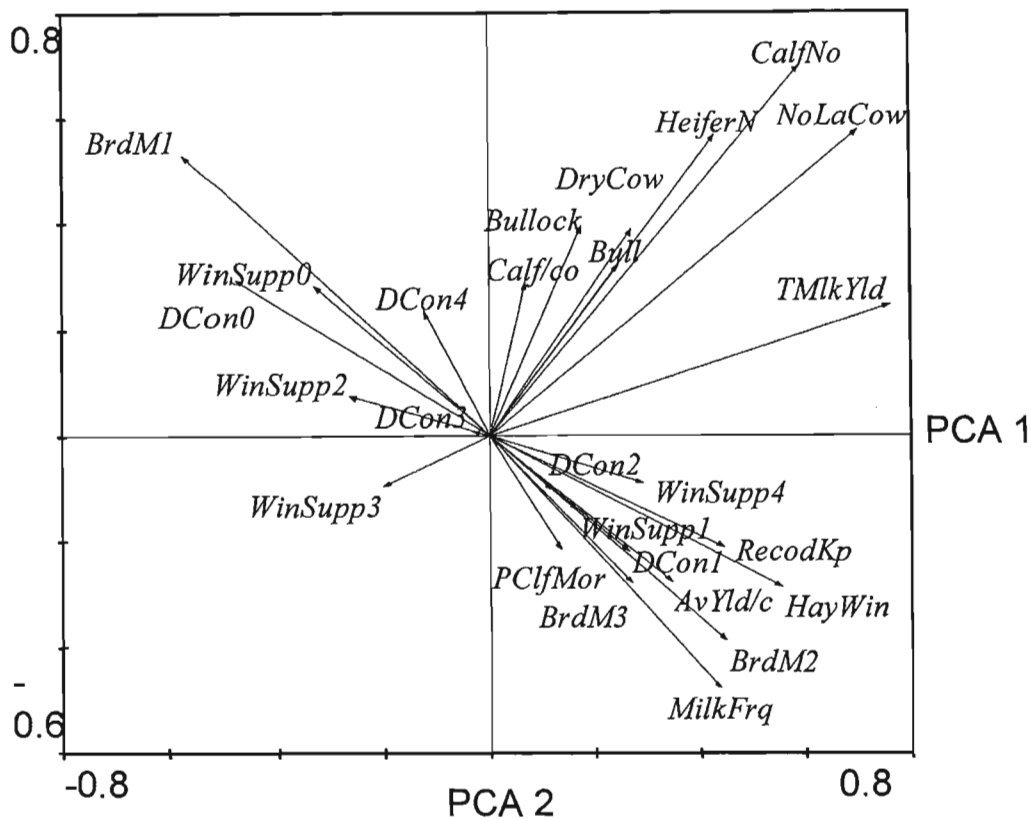


Figure 3.5: Principal components analysis, scatter plot of performance and management variables recorded for 118 smallholder dairy farmers in Swaziland (Manzini region and surrounding areas). The eigenvalues for axis 1= 0.138 and axis 2= 0.116 and account for 13.8% and 11.6%, respectively, of the variation in farm management and performance. (**NoLaCows** - Number of lactating cows, **HeiferNo** - No. of heifers, **CalfNo** - No. of calves, **DryCows** - No. of dry cows, **Bullock** - No. of bullocks, **Bull** - No. of bulls, **Calf/cow** - calf to cow ratio, **TmlkYld** - total milk yield per farm, **MilkFrq** - milking frequency, **PClfMort** - proportional calf mortalities, **AvYld/co** - average milk yield per cow, **RecordKpg** - record keeping, **HayWin** - winter hay feeding, **BrdM1** - breeding exclusively using bulls, **BrdM2** - breeding exclusively using artificial insemination (AI), **BrdM3** - breeding using a combination of both AI and bulls, **Dcon0** - no dairy concentrate fed, **Dcon1** - feeding whole commercial dairy concentrate, **Dcon2** - feeding a mix of commercial dairy concentrate and hominy chop on a 1:1 (volume) basis, **Dcon3** - commercial dairy concentrate occasionally fed, **Dcon4** - feeding home made rations to supplement milk production, **WinSupp0** - no winter feed supplementation, **WinSupp1** - winter feed supplementation with dry fodder only (hay and/or maize stover), **WinSupp2** - winter feed supplementation on winter pasture, silage or yellow maize, **WinSupp3** - winter feed supplementation on molasses meal, **WinSupp4** - winter feed supplementation on dry fodder, yellow maize and maize silage or fattening ration).

A plot of loadings of management and performance variables in the PCA, (Figure 3.5) reveals that the farmers that had the most number of lactating cows also had higher total milk yields per farm (*TMilkYld*). These farms also had higher numbers of calves, heifers, dry cows, bullocks and bulls. In accordance with the findings of Weldeselasia (2003), average milk yield per cow (*AvYld/co*) however appears to be positively but very poorly correlated to both total milk yield per farm (*TMilkYld*) and number of lactating cows (*NoLaCows*), indicating that the efficiency of milk yield per cow is not significantly related to the number of lactating cows on the farm. This relates to the trends revealed by clustering (Table 4.1 and 4.3), emphasising that the farmers' approach to increasing milk yields is by increasing the number of lactating cows as opposed to improving the milk production efficiency per cow. This confirms the above argument on success perceptions of the farmers and further concurs with the observations of Weldeselasia (2003). Bergevoet *et al.* (2004) reported that there is a significant relationship between behaviour and the goals and intentions of farmers, a point clearly illustrated above. On the other hand the ordination plot shows a high positive correlation of average milk yield per cow to two out of the three breeding systems practised i.e. exclusively AI (*BrdM2*) and a combination of both AI and bulls (*BrdM3*).

The third method, breeding exclusively using bulls (*BrdM1*) is highly negatively correlated to average milk yield per cow (*AvYld/co*). This could be a result of the fact that the farmers that practice this breeding method (*BrdM1*) invariably employed poor farm management practises, a fact validated by the high negative correlation of *BrdM1* to milking frequency (*MilkFrq*), winter hay feeding (*HayWin*), record keeping (*RecodKpg*) and good winter-feed supplementation (*WinSupp*), which are all highly positively correlated to average milk yield per cow (*AvYld/co*). In contrast, Weldeselasia (2003) observed that in Eritrea, average milk yield/cow/day was significantly influenced by farmer location but not by herd size, access to health services or the farmer's status.

The farms that fed whole commercial dairy concentrates (*Dcon1*) and those that fed the commercial concentrates mixed with hominy chop (*Dcon2*) on a 1:1 (volume) basis had higher average milk yield per cow than those that either did not feed any dairy concentrates (*Dcon0*), occasionally fed commercial dairy concentrates (*Dcon3*) or fed home made rations to lactating cows (*Dcon4*). The implication, therefore, is that the farms with high average milk yield per cow are those with high or efficient levels of management. Weldeselasia (2003) reported that all the farmers fed commercial dairy concentrate as a supplement to the forage and fodder they had either grown or bought. The Swazi smallholder dairy farmers on the other hand do not ordinarily provide fodder and forage, save for naturally growing grass and maize stover remaining after grain harvesting. The main constraints on these being the scarcity of land, water and skills for fodder production and conservation. In addition to these, the availability of fodder for sale is very scarce and expensive.

Relative calf mortality (*PClfMort*) has a very low negative correlation to both calf numbers (*CalfNo*) and the number of lactating cows (*NoLaCows*). The high relative calf mortalities observed in clusters 2 and 3 (Table 4.3) are primarily due to the low number of calves that these groups of farmers had (Table 4.1). Since relative calf mortality was calculated as a proportion of the total number of calves in each farm, those farms that had a few calves and had lost calves were consequently shown to have higher percentage calf mortalities. Milking frequency is, however, positively correlated to calf mortality, implying perhaps that the calf rearing skills of some of the farmers that milk twice daily are not up to standard. It is also possible that the farmers focus more on increasing milk yield and in the process obviously sacrifice the calves since a number of them practice controlled suckling of calves on the dams after each milking session. According to Ryle and Ørskov (1990), suckling can increase milk yields and may reduce the incidence of mastitis, as well as prolong lactation. This, therefore, implies that the farmers need to be educated on how to efficiently practise controlled suckling so as to achieve its beneficial effects.

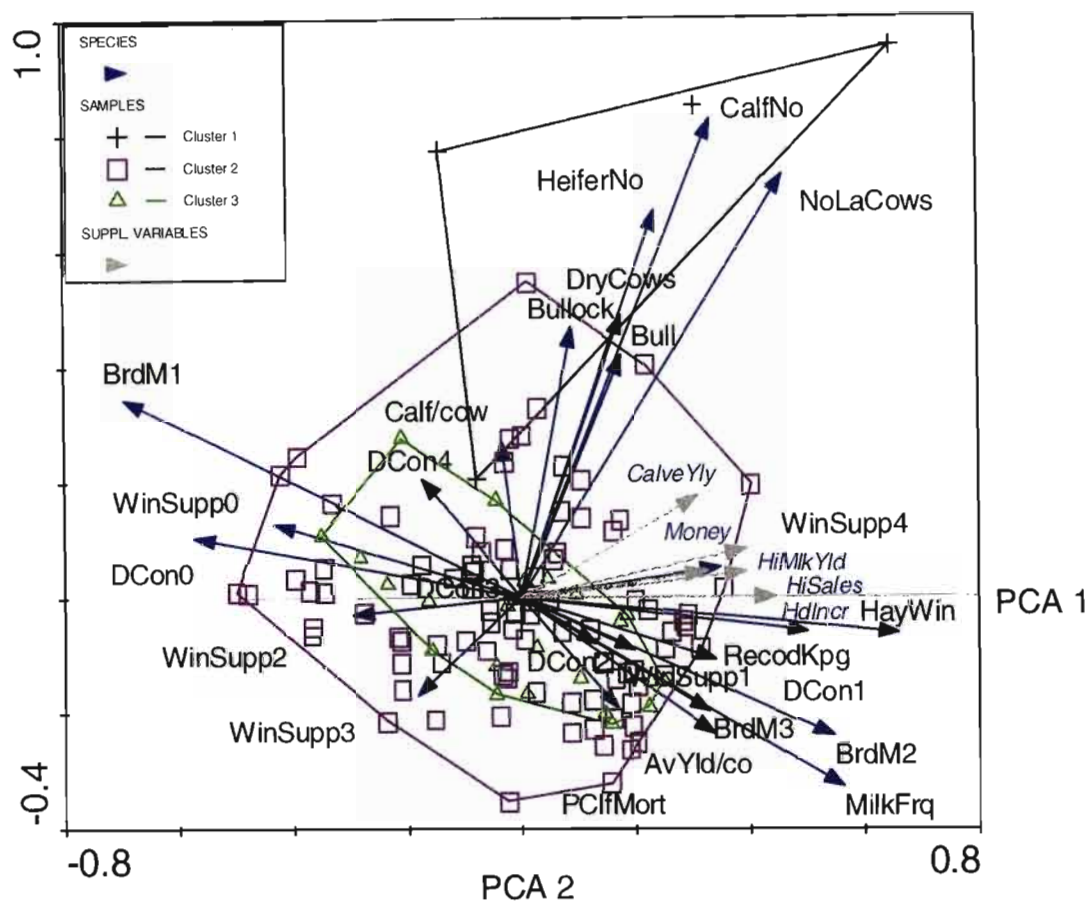


Figure 3.6: PCA Triplot of samples (farmers) species (herd structure, management and performance) and supplementary variables (farmers' perception of success) obtained from a survey on smallholder dairy farming in Swaziland (Manzini region and surrounding areas). The eigenvalues for axis 1= 0.507 and axis 2= 0.218 and account for 13.8% and 11.6% respectively of the variation in farm management and performance. The farmers are grouped according to the clusters compiled in SAS (Table 4.1).

(**NoLaCows** - Number of lactating cows, **HeiferNo** - No. of heifers, **CalvNo** - No. of calves, **DryCows** - No. of dry cows, **Bullock** - No. of bullocks, **Bull** - No. of bulls, **Calf/cow** - calf to cow ratio, **TMkYld** - total milk yield per farm, **MilkFrq** - milking frequency, **PClfMort** - proportional calf mortalities, **AvYld/co** - average milk yield per cow, **RecordKpg** - record keeping, **HayWin** - winter hay feeding, **BrDM1** - breeding exclusively using bulls, **BrDM2** - breeding exclusively using artificial insemination (AI), **BrDM3** - breeding using a combination of both AI and bulls, **Dcon0** - no dairy concentrate fed, **Dcon1** - feeding whole commercial dairy concentrate, **Dcon2** - feeding a mix of commercial dairy concentrate and hominy chop on a 1:1 (volume) basis, **Dcon3** - commercial dairy concentrate occasionally fed, **Dcon4** - feeding home made rations to supplement milk production, **WinSupp0** - no winter feed supplementation, **WinSupp1** - winter feed supplementation with dry fodder only (hay and/or maize stover), **WinSupp2** - winter feed supplementation on winter pasture, silage or yellow maize, **WinSupp3** - winter feed supplementation on molasses meal, **WinSupp4** - winter feed supplementation on dry fodder, yellow maize and maize silage or fattening ration. **CalveYly** - annual calving of cows, **HdIncr** - increasing the herd size, **HiMkYld** - high milk yields, **HiSales** - high milk sales, **Money** - making money).

All the supplementary variables (success perceptions of farmers) were strongly positively correlated to PCA axis 1 and not to axis 2, save for **CalveYly** (annual calving of cows), which was positively correlated to both PCA axis 1 & 2 (Figure 3.6). The PCA triplot (Figure 3.6) shows the farmer clusters in relation to the herd structure, management, performance and success perception variables measured in the field. The above PCA triplot revealed some similarities between some members of the different clusters in relation to certain management variables, especially members of clusters 2 and 3. Clusters 2 and 3 appear to be very similar, primarily because of the small differences in their herd structures as opposed to cluster 1, which is overtly different mainly due to the large herd sizes of the farms in this cluster. These similarities are also shown in the subtle differences in the means of both management and farmer success perception variables for clusters 2 and 3 in Table 4.3.

4.4 Conclusion

The Swazi smallholder dairy farmers can conclusively be classified into three groups, based mainly on their herd structures, sizes, management systems and success perceptions in dairying. The majority of farmers have intermediate herd sizes and high relative calf mortality. The average milk yield per cow is very low across all clusters and there is poor nutritional supplementation of the animals in the dry season. Most farmers appear to be indifferent about the importance of annual calving of cows to their dairy enterprises. There is evidently a great need for the enlightenment of the farmers on the importance of good nutrition, breeding and calf rearing to the success of their dairy projects. Record keeping is an abstract concept to most of the farmers, since they see it as just a waste of time. As record keeping is an integral part of good management, it is imperative that the farmers be helped to appreciate the essential and practical nature of record keeping in dairying. This, from a business perspective would enable them to easily account for invested resources, production levels and revenue received.

Chapter V

5.0 General Discussion And Conclusion

Swaziland has long had a disparity between the supply and demand of milk and while the quantitative contribution of the large and medium scale commercial farmers to milk supply in the country is known, that of smallholder farmers has remained virtually unknown and hence open to speculation. Although this study was not aimed at quantifying the milk production capacity of smallholder farmers, the productivity of their cattle was evaluated and was found to be below expectation, emanating from a myriad of reasons. There is generally low milk production efficiency per cow, which farmers appear to compensate for by increasing the numbers of lactating animals. Given the fact that land and feed are scarce and both costly resources, increasing animal numbers has the potential to further exacerbate the problem. The solution would be to improve the milk-yielding efficiency per cow by acquiring cows of high genetic merit and good management of their breeding and nutrition.

The major constraints to smallholder dairying in Swaziland were identified to be: poor knowledge of appropriate dairy husbandry practices, inadequate extension service provision, poor animal nutrition, high costs of feed, poor pasture & fodder production, land availability and ownership, dairy stock availability, poor heat detection, poor breeding systems, calf rearing practices, unfavourable milk prices in the formal market and poor organisation and infrastructure in the informal milk market. The poor breeding systems (i.e. heavy reliance on natural breeding using unregistered dairy and non-dairy bulls) are a result of the fact that most farmers do not own bulls and there is poor AI service utilisation due to poor record keeping, poor communication with AI technicians and poor heat detection. The marketing of milk in the informal market means that the farmers get paid in small amounts daily and as a result end up using the revenue for household expenses and ultimately do not have enough money to purchase dairy concentrates, hence the intermittent and transient feeding of supplements.

There was generally poor pasture establishment, fodder production and conservation on most farms. Pasture and fodder are both considerably a cheaper source of nutrition than the feeding of total mixed rations or the substitute feeding of dairy concentrates, which some farmers were observed to be practising. The most commonly fed fodder type is maize stover, since almost every homestead grows maize in the wet season. The feeding of dairy concentrates is primarily limited by cost and availability. The feed manufacturing factories and retailers are concentrated in the hub of the country (Matsapha in the Manzini region) and the major towns and cities, respectively. On the other hand, the majority of farmers are located in the rural areas, which in turn are distant from the feed supply sources, making it difficult and expensive for farmers to access dairy concentrates. Although some feed supply depots, belonging to some feed manufacturers are present in some rural areas, they are still considerably far from most smallholder farmers. The farmer co-operative depots also retail animal feed but often run out of stock or do not have fresh feed because of the inconsistent feed demand from smallholder farmers, owing to their lack of finances and transport.

Previous studies (Dlamini, 1990; Ogwang, 1993; Dlamini & Khumalo, 2000) on Swazi smallholder dairying have ascertained that the major constraints to pasture development and fodder conservation are the lack of finances, skills, knowledge, equipment, and land and in some instances water scarcity. While some farmers try to establish pastures, fodder production and conservation on the other hand have been and presently remain a foreign concept to Swazi smallholder farmers, a practise that has never been a part of traditional livestock farming in Swaziland. Traditionally, after the harvesting of maize cobs, the stover would be left behind and cattle are allowed to graze on it. The active production and conservation of fodder is an involving and labour intensive process, to which many farmers may be reluctant to commit. In addition to the absence of fodder production practices, besides grasses, hardly any research has been conducted to determine the types of fodder crops and cultivars suitable for rain-fed production in the different agro-ecological zones of

Swaziland. The cultivation of such crops would be most suitable in the dry season, when ordinarily the crop fields remain fallow after the harvesting of maize grain.

5.1 Conclusion & Recommendations

In order to improve the current state of affairs in smallholder dairying, there has to be a concerted effort from all stake holders in the industry geared towards improvement. The level of extension service currently provided by the government and SDDB has to be intensified, with the two organisations working in close collaboration to educate and advise farmers, including regular farm visits. A great deal of effort has to go into educating farmers on proper dairy husbandry practices, cattle reproduction and heat detection, record keeping, calf rearing and the importance of good nutrition (including pasture and fodder production and feeding). The issue of stock availability can be addressed by the establishment of an efficient breeding system at the Gege government dairy farm, as originally envisaged to provide pedigree animals to smallholder farmers at reasonably low cost. This exercise would be similar to the well established and ongoing national beef herd improvement breeding project, which is implemented through the loaning of pedigree bulls to individual farmers, both smallholders and ranchers.

The AI service provision should be improved, either by increasing the number of SDDB technicians or by increasing the numbers of AI skilled farmers to provide service efficiently in their communities. If the latter is to work efficiently, there needs to be a review of the current community based AI service provision, to ensure that the flaws of the programme are rectified and incentives are provided for the AI skilled farmers who provide the service. In addition to improving the AI service provision, the establishment of more milk collection centres has the potential to boost milk production. This is, however, on condition that improvements are made in the organisation of farmers into co-operative societies, the location of the milk collection centres, milk collection systems and the prices at which the

milk and its products are sold, so as to improve the revenue of farmers and ensure the sustainability of such business ventures.

Dairying, like every agricultural enterprise is a business venture and hence the farmers are engaged in farming mainly to make money. In Swaziland the price of milk is subject to the market forces of demand and supply, hence farmers have no control over it and at present find it unfavourable to them. Given that smallholder farmers do not have the advantage of economies of scale in their production, an alternative way to keep them in business is by increasing the efficiency of milk production. In animal production, feed costs are generally known to account for about 70% of total production costs. It follows therefore that a reduction in feed expenditure without compromise on quality and quantity could greatly increase the efficiency of production. This can be achieved by placing the cattle on a basal diet of pasture and fodder, with commercial dairy concentrate fed specifically as a supplement and not the substitution type feeding currently practised by many farmers.

As much as the current and previous studies have helped shed some light into the dynamics of smallholder dairying in Swaziland, it would be advisable that further studies be conducted on the different aspects of dairying in order for a clear understanding of the system to be achieved. On an economic perspective, establishing the optimum size and level of operation at which smallholder farmers would break even in their enterprises is vital if they are to be advised on how best to make money in the industry. In addition, understanding the dynamics of the current milk marketing channels and systems can perhaps lead to the realisation of how best to market the produced milk and suggest possible value adding operations (processing, packaging & distribution) prior to marketing. Adaptive research should be conducted on the possible fodder crops that can be grown either through intercropping or during the dry season in the different agro-ecological zones for dry season consumption, so as to improve the nutrition of the cattle in the dry season.

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Annex 1

Pictures Showing the Housing, Milking, Feeding, Fodder production & Conservation



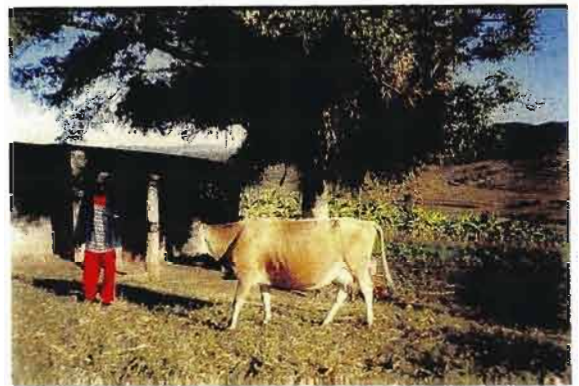
Conservation Of Grass & Maize Stover



Chopping Stover



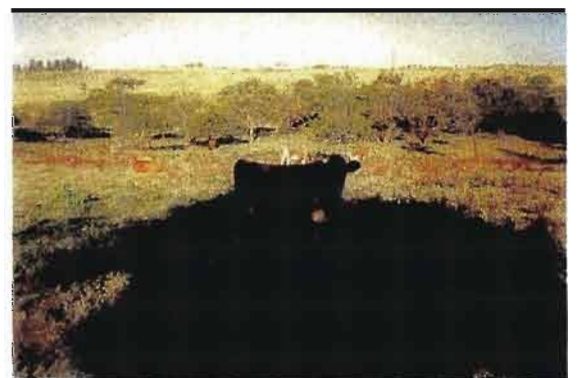
Hay Bales, Stored For Dry Season Feeding



Maize Stover Conserved On tree



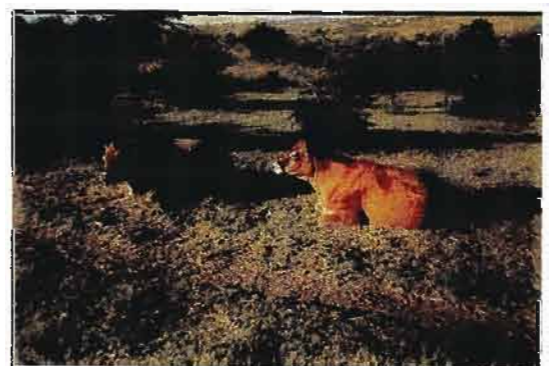
Maize Stover Conservation



Grazing Cow



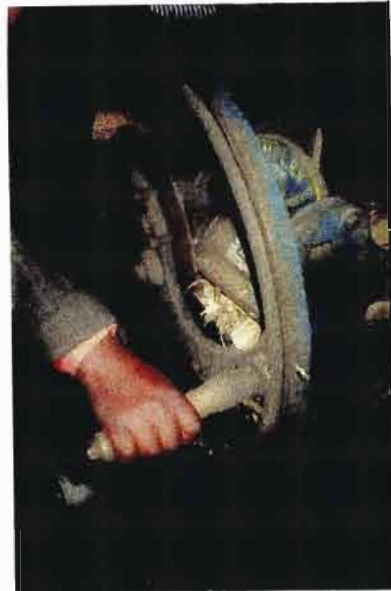
Elephant Grass



Jersey Cows Chewing the Cud



Stover Fed Into Chopper



Chopping Maize Stover



Feeding Hay & Crushed Yellow Maize



Udder & Teat Cleaning Prior To Milking



Brick House, Single Milking Parlour



Strip Cup Testing Of Milk Prior To Milking



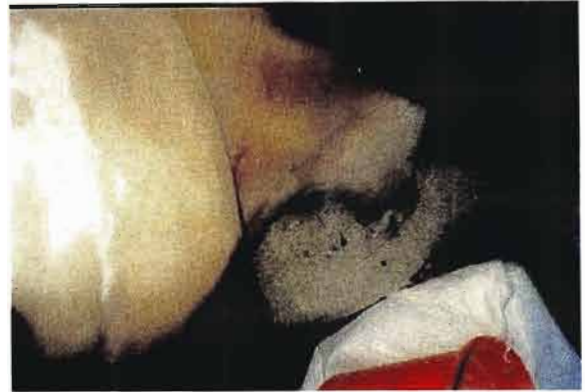
Hand Milking



Milking Buckets



Hominy Chop



Feeding Hominy Chop & Dairy Concentrate Mix



Hominy Chop & Dairy Concentrate Mix



Feeding A Home Made Ration



Cattle Fed During Milking In The Open



Natural Fermentation Of Milk In Whey Draining Buckets



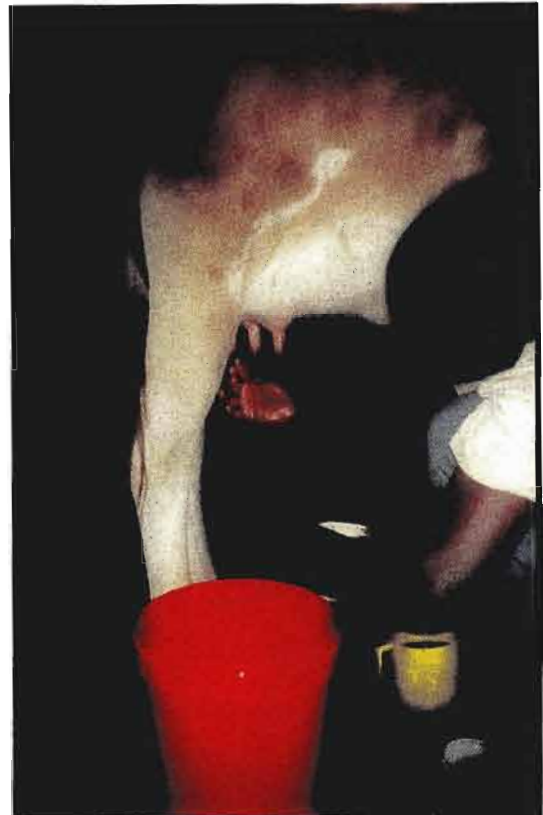
Milk Packaging For Customers In Buckets



Dry Season Supplementary feeding



Teat Dipping In Iodine After Milking



Milking Cream Application



Dry Season Grazing Between Crop Fields



Pre-milking Rest